ASSESSMENT OF THE EPA-SWMM SOFTWARE FOR URBAN STORMWATER MANAGEMENT MANUAL (MSMA) REQUIREMENT

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Assessment of the EPA-SWMM Software for Urban Stormwater Management Manual (MSMA) Requirement

by

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Dissertation submitted in partial fulfilment of
the requirements for the
Bachelor of Engineering (Hons)
(Civil Engineering)

JUNE 2010

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
Civil Engineering Programme
Universiti Teknologi PETRONAS
in partial fulfilment of the requirement for the
BACHELOR OF ENGINEERING (Hons)
(CIVIL ENGINEERING)

Approved by,

____

(Ms. Husna Bt. Takaijudin)

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
June 2010

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

INTAN MASTURA BT. MOHAMAD AZMI

ABSTRACT

Nowadays, progressive development from agriculture to an industrialized economy has grown rapidly not only in Malaysia but also in many countries all over the world. However, inadequate controlled development has resulted to the environmental changes and problems such as flash flood in both urban and rural areas in Malaysia. The case study of this project is located at the New Academic Complex of Universiti Teknologi PETRONAS (UTP). The purposes of this project are to identify and investigate the assessment of the EPA Storm Water Management Model (EPA SWMM) for urban stormwater management in order to meet the MSMA requirement and make a comparison with manual calculation in term of the physical quantity. Therefore, this study is conducted with the aid of EPA SWMM computer model in order to determine the peak runoff for post-development area. Using EPA SWMM gave satisfying results and it is suitable for simulating post-development area. However, EPA SWMM has used different approaches of design analysis compared to MSMA manual practices. In EPA SWMM, it only considers the runoff for post-development area but in MSMA practices, it being considered the runoff in both, the pre-development area and post-development area. Besides that, MSMA manual proposed Rational Method to compute peak runoff. Rational Method does not produce Hydrograph but in EPA SWMM, it generates the Hydrograph to set the peak runoff. Thus, some of modifications are needed in EPA SWMM in order to fulfill MSMA requirement. All in all, the computer models are very important tools to help engineers perform their task faster, cheaper and better way.

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CHAPTER 1
INTRODUCTION

1.1 BACKGROUND

Nowadays, progressive development from agriculture to an industrialized economy has grown rapidly not only in Malaysia but also in many countries all over the world. Urban development is affected by urban population and it will continue in the developing countries. It is necessarily to meet the needs of population. However, inadequate controlled development has resulted to the environmental changes and problems such as flash flood in both urban and rural areas in Malaysia. In fact, these activities are responsible for increased runoff and domestic waste such as nutrients, oil, heavy metals, bacteria and others in our rivers. As a result of these activities, incident of flash flood becoming one of the major problems and the scenario has become more critical over the years in big cities in Malaysia. As the country continues to urbanize, the flood problem continue to increase. (Zakaria & Ainan, 2000).

Flash flood rarely causes death but it causes large property damage and economic losses. In Malaysia, the average annual flood damage is estimated at RM 100 million per year. To overcome these flash flood phenomena, Department of Irrigation and Drainage Malaysia (DID) estimates that RM 10 billion (reported in News Straits Times, June 22, 2000) is required to upgrade the conventional drainage system made up of concrete channels and channelized rivers.

Due to this problem, Department of Irrigation and Drainage (DID) Malaysia has prepared the second urban drainage manual which is titled Storm Water Management Manual for Malaysia (MSMA) to replaced the old manual "Planning and Design Procedure No.1: Urban Drainage Design Standard For Peninsular Malaysia, 1957". The new manual is unique in many aspects compared with the old manual. It is more comprehensive, taking into consideration the present problems facing by the nation such as flash flood, river pollution, soil erosion, development in the highlands and lowlands and so on. (MSMA, 2000). This manual is environmentally friendly and is based on 'control-at-source' approach instead of the former approach of 'rapid disposal'. This approach is a new concept in stormwater management practices in Malaysia and the main focus is to manage the stormwater instead of draining it away as fast as possible to a more environmentally approach. (Ainan, et al., 2004). As a result, the zero development impact contribution in both quality and quantity of the runoff can be sustained. (Sidek, et al., 2004). Effective from 1st January 2001, the introduction of MSMA as a new guideline for urban stormwater management has been welcome by many parties as an important step in the management of water resources in Malaysia.

Computer models are very important to engineers because they can help engineers completing their task in a faster, cheaper and more accurate designs compare to tedious and time-consuming manual calculations. (Bing Zhao, 2004). Many new computational software have been developed world-wide based on the intensive research effort in urban hydrology, hydraulics and stormwater. The United States Environemntal Protection Agency (US EPA) defines models as a set of processes which are "used to increase the level of understanding of natural or manmade systems and the way they react to varying conditions." (MSMA, 2000). In the middle of 1970, computer modeling became a part of storm drainage planning and design. (MSMA, 2000).

The analytical power of computer methods gives them major advantages compare to manual technique because the result in more accurate designs, faster with cost savings by avoiding over- or under-sizing. (MSMA, 2000). A few well-known computer modeling software, such as EPA SWMM, XP-SWMM, MOUSE, StormCAD, MIDUSS and DRAINS (ILSAX), can be applied in urban hydrological models.

The EPA Storm Water Management Model (SWMM) is a dynamic rainfall-runoff simulation model used for single event or long-term (continuous) simulation of runoff quantity and quality from primarily urban areas. (USEPA SWMM, 2009). Therefore, this final year project is conducted with the aid of EPA SWMM to identify and investigate the assessment of this software for urban stormwater management in order to meet MSMA requirement.

The study case reported in this report is located at the new academic complex of Universiti Teknologi PETRONAS (UTP). This case study area is approximately 61 hectares. The overall layout of the new academic complex is in the shape of a five-pointed star made up by five semicircles.

1.2 PROBLEM STATEMENT

In Peninsular Malaysia, the annual mean rainfall is approximately 2,540 mm, with most precipitation occurring during the southwest monsoon (September to December) and the total annual surface water resources is estimated at 147 billion $m^{3.}$ Rapid urbanization, which modified the hydrological processes of a catchment, is responsible for many related problems in urban areas, especially in the topical regions. The consequence of rapid and uncontrolled development project has impact in frequent flooding in Malaysia.

A few years back, flash flood problem become aggravate since the drainage system cannot cope the intensity of the rainfall. In Malaysia, flooding can be divided into two categorized which are the seasonal monsoon floods and the unpredictable flash floods. Flash flood happened because of the high intensity in short duration rainfall.

Flash flood is slightly different from normal floods. Flash flood is floods that happen very fast and with little warning. Flash flood cause loss of lives, damage properties and buildings, and disturb human activities especially in the aspects of economic. Inadequate drainage system, changes in land use for urban development and illegal logging activity are the reasons that worsen the flood problem.

Nowadays, there are numerous computer models related to stormwater systems design have been developed. Due to the accuracy of the produced result and reliable, simulation of streamflow with conventional method has been replaced by modeling method. Various kinds of computer models have been developed by foreign experts to analyse one or many problems encountered in storm drainage systems. Most of the computer models are based on hydrology, hydraulics and stormwater quality. The choice of the model to be applied depends on the objective of the modeling and the data availability.

This computer models gives major advantages over manual techniques. The computer models are an easy tool for analysis and design in an engineering study. Besides help engineers perform tasks in a faster with cost saving, computer models also allow better visualization and observation. However, it should be borne in mind that proper use of such a new method or tool requires a good knowledge of the detailed operations that the method or tool can perform. (MSMA, 2000)

Computer models allow some types of simulations to be performed that could rarely be performed otherwise, since periods of runoff or quality measurement in urban areas are seldom very long. It should always be borne in mind; however, that use of measured data is usually preferable to the use of simulated data. Modeling is not good substitute for data collection, especially for water quality parameters. Although modeling is generally cheaper than data collection, the uncertainties involved, especially in water quality simulation, mandate the collection of data for model calibration and verification. (MSMA, 2000).

1.3 OBJECTIVE OF THE STUDY

The purpose of this study are shown as below :

i. To identify and investigate the assessment of the EPA Storm Water Management Model (EPA SWMM) for urban stormwater management in order to meet the MSMA requirement.

ii. To make a comparison with manual calculation in term of the physical quantity.

1.4 SCOPE OF STUDY

As to achieve the objective of the study with the various limitations and constraints of the researcher will confined to the following scopes :

i. Select the case study area. For this project, the new academic complex of Universiti Teknologi PETRONAS (UTP) has been chosen.
ii. Carry out the case study area survey and determine the catchment characteristics of the study area.
iii. Analyse and tracing drainage network.
iv. Collection of hydrological data from Rumah Pam Bota at Perak.
v. Uses of computer model EPA-SWMM as core modeling tool for study.

CHAPTER 2
LITERATURE REVIEW

2.1 INTRODUCTION

Hydrology is defined as the science of water. It deals with the occurrence, distribution and motion of water of the earth and earth's atmosphere. As a branch of earth science, it is concerned with water on, under and above the surface of the earth. Hydrology covers a broad field of an inter-disciplinary nature drawing support from allied sciences, such as meteorology, geology, statistics, chemistry, physics and fluid mechanics. (Subramanya, 2007). Sometimes, hydrology also can be classified as :

- Scientific hydrology – a study that concerned with academic aspects
- Engineering or applied hydrology – a study that concerned with engineering applications

2.2 HYDROLOGIC CYCLE

Water may appear in all three of its states; Viz. liquid, solid and gaseous, and in various degrees of motion. Some examples of dynamic aspects of water are formation and movement of clouds, rain and snowfall and evaporation of water from water bodies. (Subramanya, 2007). Many processes work together to keep Earth's water moving in a cycle and it can be explained in terms of a cycle known as the hydrologic cycle.

Generally, hydrologic cycle is the continuous, unsteady circulation of water from the atmosphere to and under the land surface and, by various processes, back to the atmosphere. (MSMA, 2000). The processes at work in the hydrologic cycle consists of precipitation that occur primarily as rain, evaporation, interception, transpiration, infiltration, groundwater flow, lakes and ocean. Illustrated of this cycle is in Figure 2.1 below.

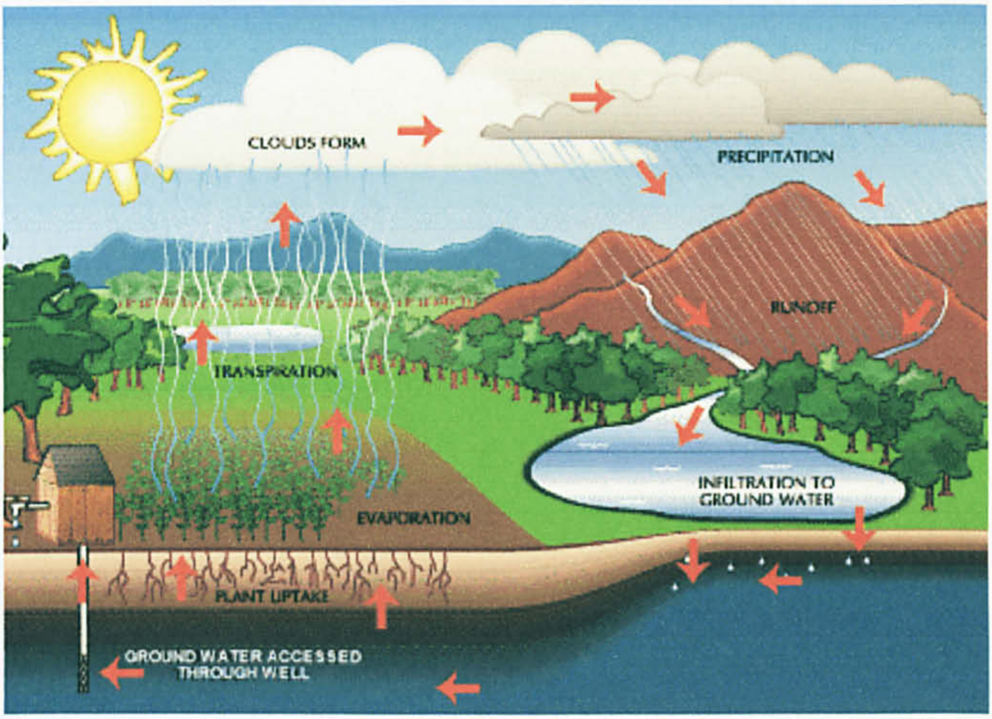

Figure 2.1 : Hydrologic Cycle

2.3 STORMWATER MANAGEMENT

To understand, control, and utilize waters in their different forms within the hydrologic cycle, stormwater management is knowledge that can be applied for these conditions. It is simply stated that everything done within a catchment to solve the existing stormwater management problems and to avoid the occurrence of new problems. Development and implementation of a combination of structural and non-structural measures are involves to reconcile the conveyance and storage function of stormwater systems within the space and related needs of an expanding urban population. Besides that, the development and implementation of a range of measures or Best Management Practices (BMPs) also involved in this management to improve the quality of urban stormwater management runoff prior to its discharge to receiving waters. (MSMA, 2000).

As the world population increases, the problems with management of urban stormwater also have been increases. Large impervious areas such as buildings and roads are constructed to improve the living standard and these activities will results in change of hydrological cycle. (Ainan, et al., 2004). Infiltration recharges will decreases, rises of surface runoff rates and volume and accelerated transport of pollutants and sediments from urban areas will occurred.

Due to these problems, stormwater management needs to be undertaken in a safer and more ecologically sustainable manner. These practices need to be wide respect to environmental issues such as water quality, aquatic habitats, riparian vegetation and social issues such as recreation and economics. (MSMA, 2000).

2.4 PREVIOUS DRAINAGE PRACTICES

The traditional approach of stormwater management widely practiced is to collect and drain runoff to the nearest drainage system like stream or lakes as quickly as possible in order to avoid flooding and protect lives and property. (James, 2004). This approach is called rapid disposal. In Malaysia, rapid disposal approach is based on the first urban drainage manual 'Planning and Design Procedure No. 1 : Urban Drainage Design Standards and Procedure for Malaysia'was published by DID in 1975. Since its publications, this manual has been used as a guildeline for more than twenty-five years, even though there have been many of new technologies developments in urban areas. (Ainan, et al., 2004).

Unfortunately, this manual was found to be insufficient to cope with the rapid rate of urbanization nowadays which led to increase the incidence of flash flood at the downstream of the catchment due to increase in surface runoff, peak discharge and others. (Ainan, et al., 2004). Moreover, because of the weakness of current practice invites more polluted river, garbage and floating litters and increase of sedimentation in the river system and has worsened the quality of life in urban community. For that reason, this rapid disposal approach is no longer effective measure in solving flood.

In order to overcome the above problem, DID has been introduced a new revised manual on urban storm water management known as Urban Stormwater Management Manual for Malaysia (MSMA) to replace the old manual. Effective from 1st January 2001, this new manual is more environmentally friendly and requires the applications of Best Management Practice (BMPs) as this manual utilizes the concept of stormwater management control at source instead of the former approach of rapid disposal approach which is to drain the stormwater runoff away of the catchments as fast as possible. (Lai, et al., 2009).

2.5 URBAN STORMWATER MANAGEMENT MANUAL FOR MALAYSIA (MSMA)

It has been more than eight years since Urban Stormwater Management Manual for Malaysia (MSMA) is introduced in 1st January 2001 by Department of Irrigation and Drainage DID Malaysia to replace the old manual "Planning and Design Procedure No. 1 : Urban Drainage Design Standards and Procedure for Malaysia, 1975". The introduction of MSMA as a new guideline for urban stormwater management has received a good response from many parties as an important step in the management of water resources in Malaysia and it cover wider scope and need to consider all factors of development that can give increase in the incidence of flood. (Ainan, et al., 2004). The aim of this manual is to provide guidance to all regulators, planners and designers who are involved in stormwater management. By using unique techniques as recommended in the manual based on site conditions and suitability of the soil, the engineers can become more innovative and creative in their design. (Sidek, et al., 2004).

This current manual utilizes control at source approach and can be divided into three main parts, which include water quantity control, erosion and sediment control, and water quality control. (Md Noh, 2008). It requires the application of Best Management Practices (BMPs) to control stormwater from the aspect of quantity and quality runoff in order to achieve zero development impact contribution. (Lai, et al., 2009). As a result, the quantity and quality of the runoff from development area can be sustained to be the similar as pre-development condition.

The new MSMA manual describes on variety approach of BMPs are becoming very popular topics for development of urban drainage in developed countries and now it is being practices worldwide. United Kingdom, United States, Germany, Australia, and Japan are widely used BMPs in drainage planning. (Lai, et al., 2009). This new approach is more environmental friendly and it capable of being combining with other facilities. (Ainan, et al., 2004).

2.6 URBAN STORMWATER MODELING

Computer models are very important to engineers since they can help engineers complete their tasks in a faster, cheaper and better way. In the middle of 1970, computer modeling became an integral part of the storm drainage planning and design. (MSMA, 2000). There are several of computer models for analysing and designing stormwater management have been developed world-wide based on the intensive research effort in urban hydrology, hydraulics and stormwater quality.

Hydrologic models act to simulate rainfall-runoff processes to determine how much water and how often. Hydraulic is similar to hydrologic models, can be continuous or single event, and lumped or distributed. Water quality often require calibration to produce credible prediction and quite similar to the hydrologic and hydraulic models.

The main objective of modeling that has been emphasized by MSMA (2000) such as following :

1. To classify the urban runoff for temporal and spatial flow distribution, pollutant ranges, etc.
2. To provide input to a receiving water quality analysis.
3. To determine effects, magnitudes, locations and combinations.
4. To perform frequency analysis of hydrologic or quality parameters.
5. To provide input to economic analysis.

There are some relevant stormwater modeling that are available to the water resources and environment engineering communities such as EPA SWMM, MIDUSS, HEC-1/HMS and XP-SWMM. Table 2.1 shows the list of computer modeling software according to MSMA, 2000.

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Table 2.1 : List of Recommended Computer Modeling Software. (MSMA, 2000)

No.	Software Name	Description	Hydrology	Hydraulics				Water Quality		Planning	
			Flood Routing	Open channels, Waterways	Pipe Systems	Culverts, Bridges, Structures	Storage Routing	Pollutant Estimation	Water Quality Control	BMP Evaluation	GIS/CAD Integration
1.	HEC-1 / HMS	Conceptual Model	Event				√				Limited capability
2.	XP-RatHGL	Rational Method hydrology, steady-state hydraulics	Event		√						√
3.	DRAINS (ILSAX)	Time-Area hydrology, storage, pipe or open channel hydraulics	Event	√	√		√				Limited capability
4.	MIDUSS	Time-Area hydrology, storage, pipe or open channel hydraulics	Event		√		√				

Table 2.1 : Continued.

No.	Software Name	Description	Hydrology	Hydraulics				Water Quality		Planning	
			Flood Routing	Open channels, Waterways	Pipe Systems	Culverts, Bridges, Structures	Storage Routing	Pollutant Estimation	Water Quality Control	BMP Evaluation	GIS/CAD Integration
5.	StormCAD	Time-Area hydrology, storage, pipe hydraulics	Event		√		√				√
6.	SWMM	Integrated hydrology, pipe and open channel hydraulics, pumps, water quality, BMPs	Event or continuous	√	√		√	√	√	√	Limited capability
7.	XP-SWMM	Integrated hydrology, pipe and open channel hydraulics, pumps, water quality, BMPs	Event or continuous	√	√		√	√	√	√	Limited capability
8.	MOUSE	Pipe hydrodynamics, water quality	Event or continuous	Limited capability	√	√					Limited capability

CHAPTER 3

METHODOLOGY

3.1 OVERALL METHODOLOGY

In this project, the methodology is shown in Figure 3.1

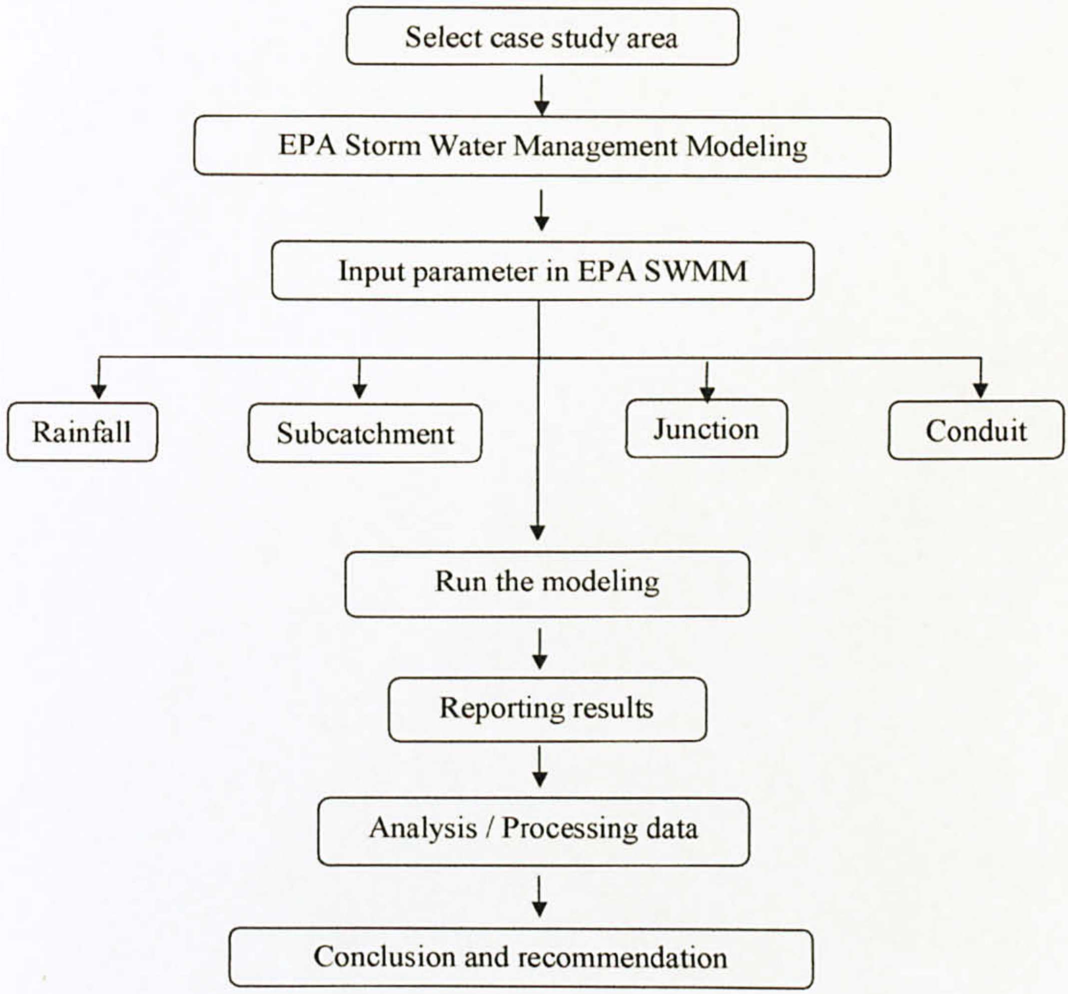

Figure 3.1 : Flow Chart of the Case Study

3.2 SELECT CASE STUDY AREA

The case study for this project is located at the New Academic Complex of Universiti Teknologi PETRONAS (UTP). The overall layout of the new academic complex is in the shape of a five-pointed star made up by five semicircles. The five pointed star is consists of Chancellor Complex, Pocket C and Pocket D. Another two buildings at the points of the new academic complex are Pocket A and Pocket B but they are yet to be built. The New Academic Complex of UTP is shown in Figure 3.2 and the detail layout is shown in Figure 3.3.

Figure 3.2 : The New Academic Complex, UTP

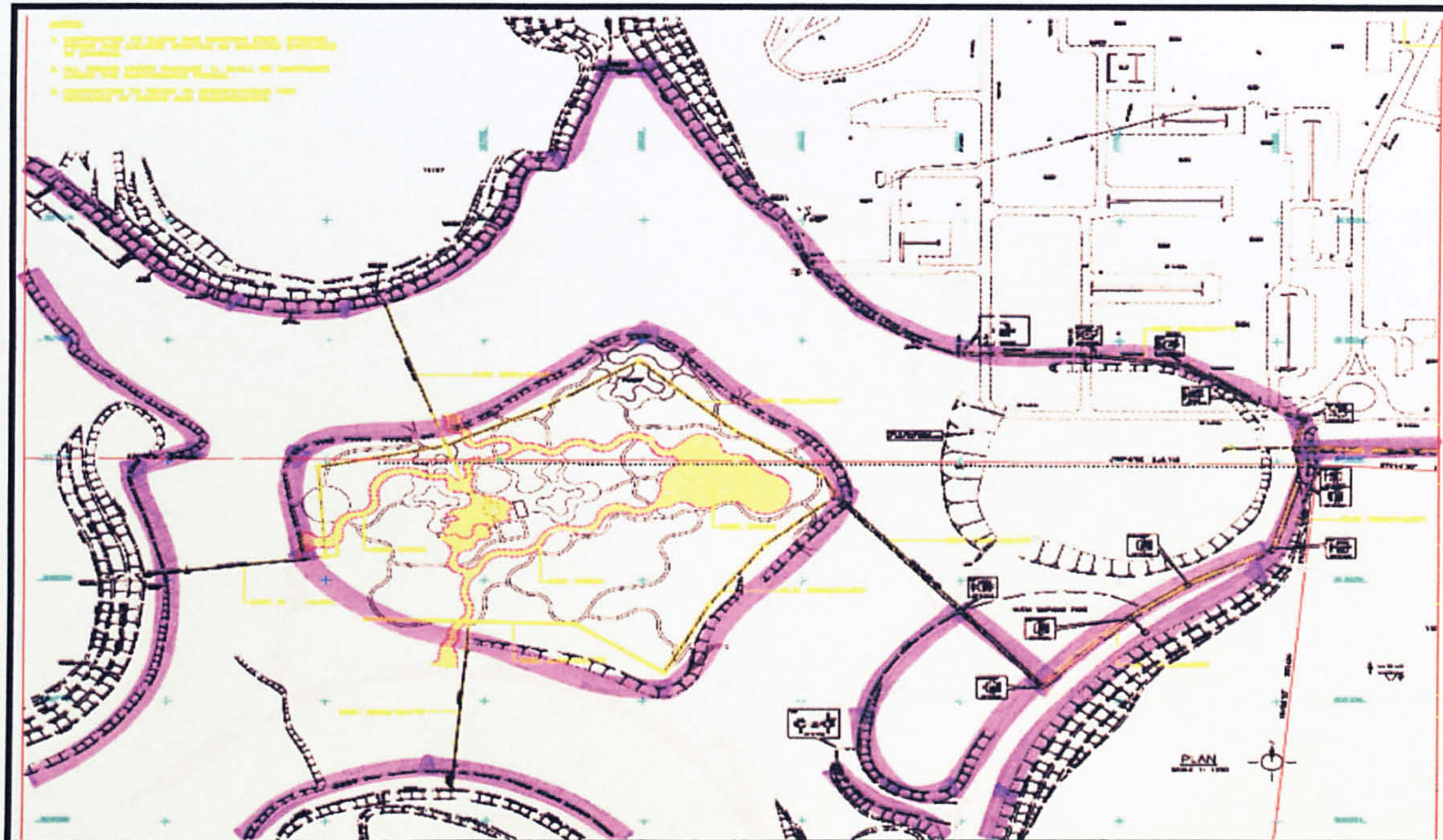

Figure 3.3 : Detail Layout of the New Academic Complex, UTP

3.3 EPA STORM WATER MANAGEMENT MODELING

3.3.1 What is EPA SWMM?

The EPA Storm Water Management Model (SWMM) is a dynamic rainfall-runoff simulation model used for single event or long-term (continuous) simulation of runoff quantity and quality from primarily urban areas. SWMM was first developed in 1971 and has undergone several major upgrades since then. It continues to be widely used throughout the world for planning, analysis and design related to storm water runoff, combined sewers, sanitary sewers, and other drainage systems in urban areas, with many applications in non-urban areas as well.

3.3.2 Model Capabilities

SWMM accounts for various hydrological processes that procedure runoff from urban areas such as :

- spatially and time-varying rainfall
- evaporation of standing surface water
- snow accumulation and melting
- rainfall interception from depression storage
- infiltration into soil layers
- interflow between groundwater & channels

SWMM also contains a flexible set of hydraulic modeling capabilities used to route runoff and external inflows through the drainage system network of pipes, channels, storage/treatment units and diversion structures. The examples of SWMM ability are :

- handles drainage network of any size
- accommodates various conduit shapes as well as irregular natural channels
- model various flow regimes such as backwater, surcharging, reverse flow and surface ponding
- model special elements such as storage/treatment units, flow dividers, pumps, weirs and orifices

In addition to modeling the generation and transport of runoff flows, SWMM can also estimate the production of pollutant loads associated with this runoff. The processes can be modeled for any number of user-defined water quality constituents such as :

- pollutant buildup over different land uses
- pollutant washoff during runoff events
- reduction in dry-weather buildup due to street cleaning
- routing of water quality constituents through the drainage system

3.3.3 Typical Application of EPA SWMM

EPA SWMM has been used in thousands of sewer and stormwater studies throughout the world. Typical application of SWMM are :

- design and sizing of drainage system components including detention facilities
- control of combined and sanitary sewer overflows

- generating non-point source pollutant loadings for wasteload allocation studies
- evaluating BMPs for sustainability goals
- flood plain mapping of natural channel systems

3.4 INPUT PARAMETER IN EPA SWMM

3.4.1 Rainfall

Daily rainfall data was taken from Rumah Pam Bota at Perak for four month from September 2009 till December 2009. The data is referred in Appendix 3.2.

3.4.2 Subcatchment Properties

- Subcatchment name
- Rain gauge
- Outlet
- Area (in acres)
- Width (in feet)
- Percent slope
- Percent impervious
- Manning's n for overland flow
- Infiltration parameters

3.4.3 Junction Properties

- Junction name
- Invert elevation (in feet)
- Maximum depth of junction

3.4.4 Conduit Properties

- Inlet node
- Outlet node
- Shape (e.g., circular)
- Maximum depth (in feet)
- Length (in feet)
- Manning's roughness coefficient
- Entry loss coefficient
- Exit loss coefficient
- Culvert code

Manning's n for Open Channels, Closed Conduits and Overland Flow is referred in Appendix 3.3.

3.5 RESULT AND ANALYSIS

The EPA Storm Water Management Model (SWMM) was used in this study. SWMM is an example of a general-purpose model capable of being used in a wide variety of water quality studies. Run the model to generate the results. Adjust the catchment parameter or adjust the model to achieve satisfactory performance.

Compare the modeling output with manual calculation (Rational Method) whether it is suitable for urban stormwater in order to meet the MSMA requirement. The result of manual calculation by using Rational Method is referred in Appendix 3.4.

CHAPTER 4
RESULTS AND DISCUSSION

4.1 PROJECT SUMMARY

This project consists of 106 catchments, 93 junction nodes and 92 conduits links. Figure 4.1 below shows the study area map for New Academic Complex of UTP in EPA SWMM.

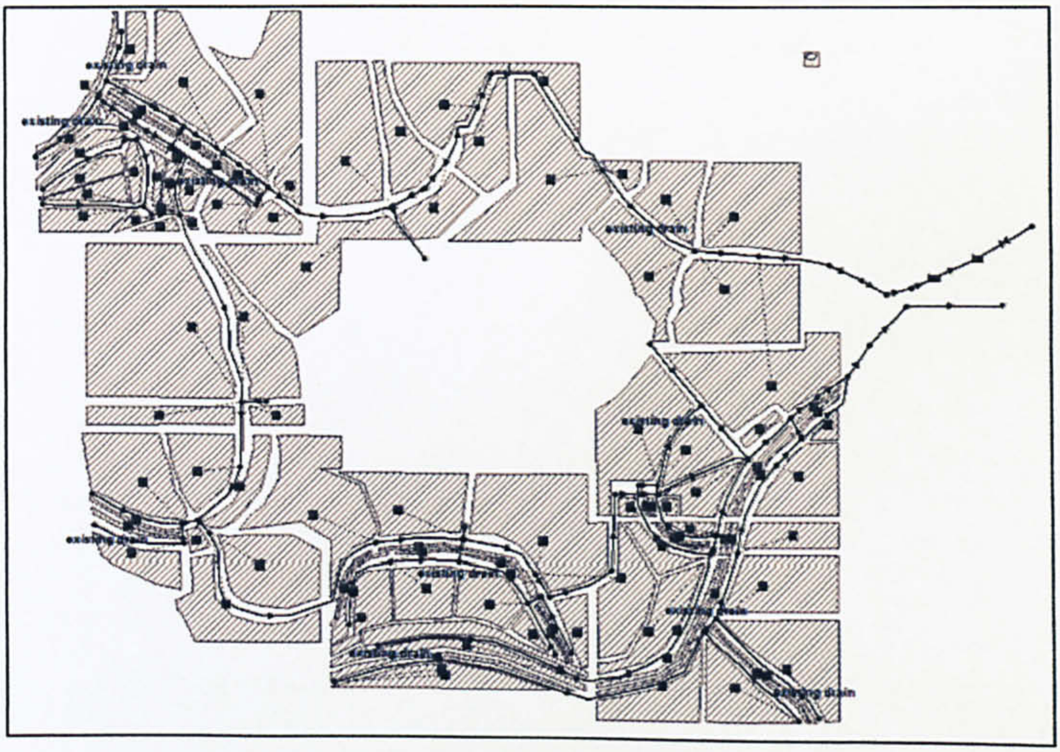

Figure 4.1 : Study Area Map for New Academic Complex of UTP

4.2 TIME SERIES

4.2.1 Time Series 1 (TS1)

The rainfall data for TS1 was taken everyday for four months from September till December 2009. Figure 4.2 shows the TSI that has been generated by EPA SWMM.

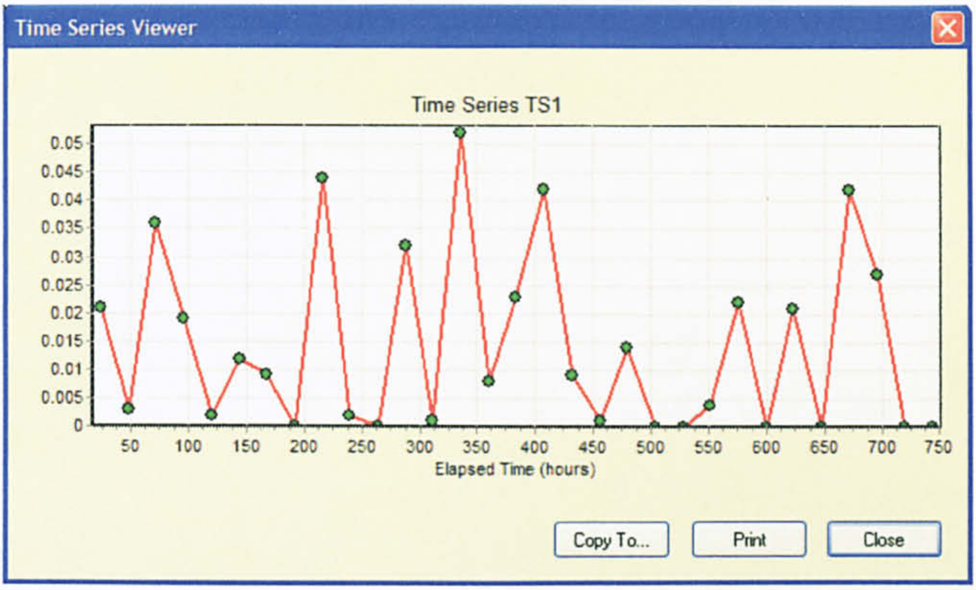

Figure 4.2 : Time Series 1

4.2.2 Time Series 2 (TS2)

In TS2, the design rainfall in 30 minutes duration has been used because the average of time concentration, t_c for each catchment in manual calculation is 30 minutes. Figure 4.3 shows the TS2 that has been generated by EPA SWMM.

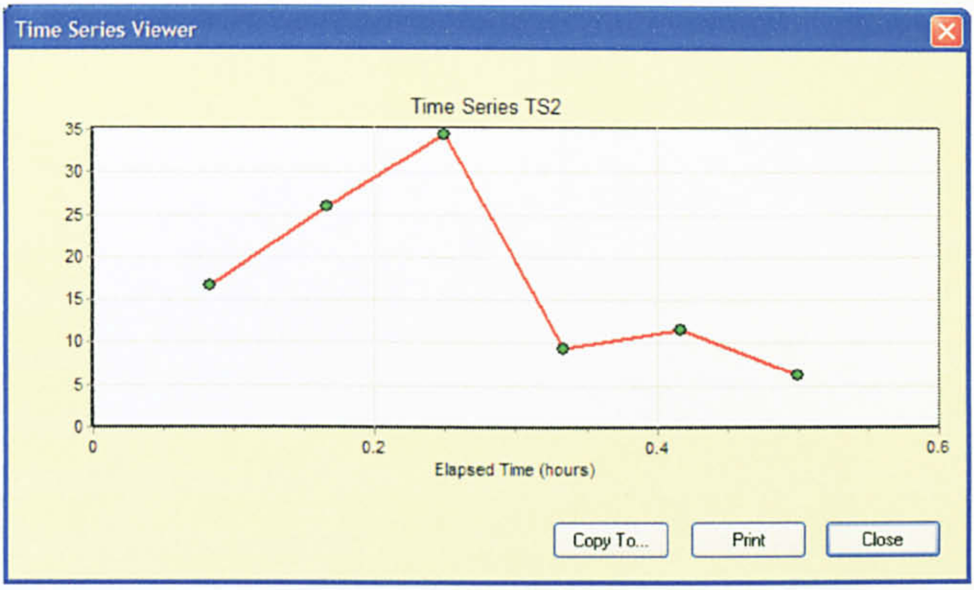

Figure 4.3 : Time Series 2

Polynomial expressions in Equation 4.1 have been used to find the rainfall intensity, I (mm/hr).

$$\ln({}^{R}I_{t}) = a + b\ln(t_c) + c\,(\ln(t_c^{2})) + d\,(\ln(t_c^{3})) \qquad (4.1)$$

where,

${}^{R}I_{t}$ = the average rainfall intensity (mm/hr) for ARI and duration

R = average return interval (years)

t_c = duration (minutes)

a to d are fitting constants dependent on ARI as in Table 13.A1 in Appendix 4.1

Table 4.1 shows the summary for calculation of rainfall intensity and has been fitted to the Ipoh IDF curves for 2-yrs ARI (MSMA, 2000) and Table 4.2 shows the temporal pattern of rainfall intensity for 30 minutes duration.

Table 4.1 : Summary for the Calculation of Rainfall Intensity 2-yrs ARI

t_c (min)	a	b	c	d	In I	I (mm/hr)
	5.2244	0.3853	-0.1970	0.0100		
	a	b (ln t_c)	c (ln t_c)^2	d (ln t_c)^3		
30	5.2244	1.3105	- 2.2789	0.3935	4.6495	104.52

Table 4.2 : Temporal Pattern of Rainfall Intensity for 30 minutes Duration

Rainfall Intensity (mm/hr)	Fraction of Rainfall in each Time Period	Average Rainfall in 30 Duration
104.52	0.160	16.723
	0.250	26.13
	0.330	34.49
	0.090	9.407
	0.110	11.497
	0.060	6.2712

From the table above, the hyetograph for average rainfall intensity in 30 minutes duration can be created and it has been shown in the Figure 4.4. The Design Temporal Patterns for West Coast of Peninsular Malaysia is referred in Appendix 4.2.

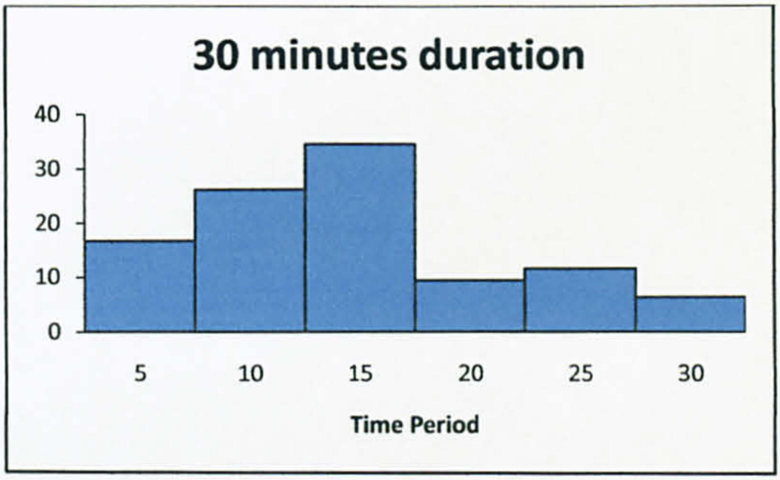

Figure 4.4 : Average Rainfall Intensity in 30 minutes Duration

4.3 STATUS REPORT

After run the EPA SWMM, the status report will show :

- Runoff Quantity Continuity
- Flow Routing Continuity
- Subcatchment Runoff Summary
- Node Depth Summary
- Node Inflow Summary
- Node Surcharge Summary
- Node Flooding Summary
- Storage Volume Summary
- Outfall Loading Summary
- Link Flow Summary

There are two types of status report since this project used 2 types of time series. Time Series 1 (TS1) is for current rainfall and Time Series 2 (TS2) is for design rainfall. The status report is referred in Appendix 4.3.

4.4 COMPARISON OF PEAK RUNOFF BETWEEN USING TS1 AND TS2

Table 4.3 shows the comparison of peak runoff that has been generated from 4 months rainfall data (TS1) and 30 minutes design rainfall (TS2). Peak runoff of subcatchment S4(3), S4(4) and S4(5) has been chosen to make the comparison.

Table 4.3 : Comparison of Peak Runoff between using TS1 or TS2

Subcatchment	Peak Runoff (m^3/s)	
	TS1	TS2
S4(3)	6.8×10^{-3}	8.882
S4(4)	2.832×10^{-5}	0.169
S4(5)	3.964×10^{-4}	0.863

The comparison shows that when TS2 which is design rainfall in 30 minutes duration has been used, the value of peak runoff will be much higher than TS1.

4.5 COMPARISON OF PEAK RUNOFF BETWEEN EPA SWMM AND MANUAL CALCULATION

The Rational Method has been used in manual calculation to determine the runoff of each catchment. The following Equation 4.2 is used to compute peak runoff using the Rational Method:

$$Q_y = \frac{C\ {}^{y}I_t\ A}{360} \qquad (4.2)$$

where,

Q_y = peak runoff (m^3/s)

C = runoff coefficient

${}^{y}I_t$ = rainfall intensity (mm/hr)

A = catchment area (ha)

Table 4.4 shows the comparison of peak runoff (generated from design rainfall) between EPA SWMM and Rational Method and Figure 4.5 shows the graph of the comparison. Result of TS2 in EPA SWMM will be used in this comparison, since Rational Method used design rainfall in order to determine the peak runoff. The catchments involved in this comparison are 7(a), 8(d) and 10(a).

Table 4.4 : Comparison of Peak Runoff (generated from design rainfall) between EPA SWMM and Rational Method

Catchment		Peak runoff (m^3/s)	
EPA SWMM	Rational Method	EPA SWMM	Rational Method
S7(1) & S7(2)	7 (a)	25.1	2.474
S8(11) & S8(12)	8 (d)	17.03	2.268
S10(15) & S10(16)	10 (a)	10.43	0.673

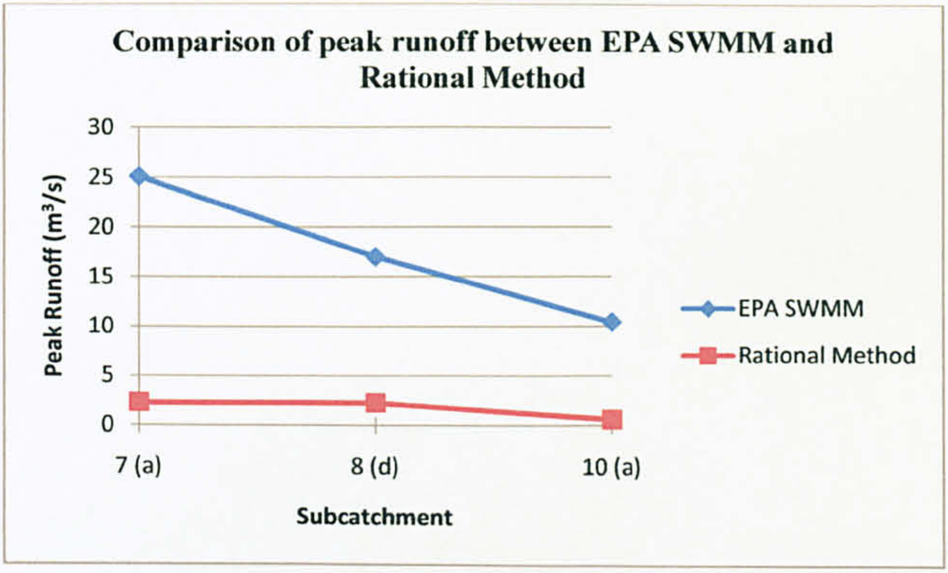

Figure 4.5 : Comparison of Peak Runoff (generated from design rainfall) between EPA SWMM and Rational Method

The result shows that EPA SWMM produces high values of peak runoff while Rational Method produces low values of peak runoff. This situation happened because the parameters used in EPA SWMM and Rational Method are different.

In term of runoff coefficients, EPA SWMM defined as the ratio of total runoff to total precipitation. While Rational Method used the recommended runoff coefficient values as the input parameter for rainfall intensities (*I*) of up to 200 mm/hr can be obtained from Design Chart for urban catchment or rural catchment respectively. These design charts are based on Australian Rainfall & Runoff, 1977. (MSMA, 2000).

Besides that, in Rational Method, time of concentration, t_c, is used as input in order to determine the rainfall intensity, *I*, while in EPA SWMM, time concentration is not used. In EPA SWMM, rainfall intensity is based on time series.

Generally, the Rational Method that is proposed by the MSMA manual to compute peak runoff but in EPA SWMM, Rational Method is not been applied. It is noticed that Rational Method does not produce Hydrograph. However, EPA SWMM generates the Hydrograph to set the peak runoff. Figure 4.6 show the curve of peak runoff.

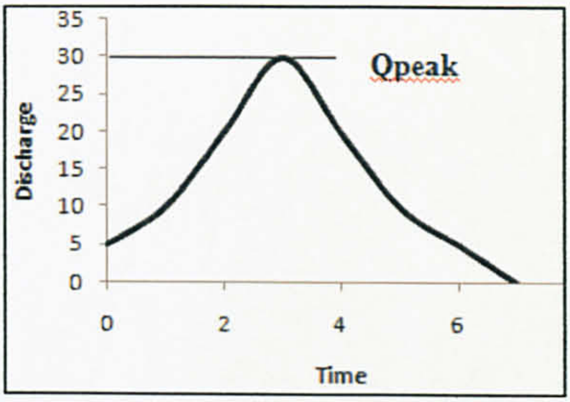

Figure 4.6 : Curve of Peak Runoff (Q_{peak})

4.6 NODE FLOODING

From the status report, the nodes flooding summary indicates there was internal flooding at different time and volume in the system. The examples of nodes that will be flooded are B5, B6, B7 and B8. Solution of this problem is redesigning again the drain size such as increase the depth of the nodes. Figure 4.7 shows the water elevation profile for node B5 – B8. The blue colour shows that internal flooding occurs in the system.

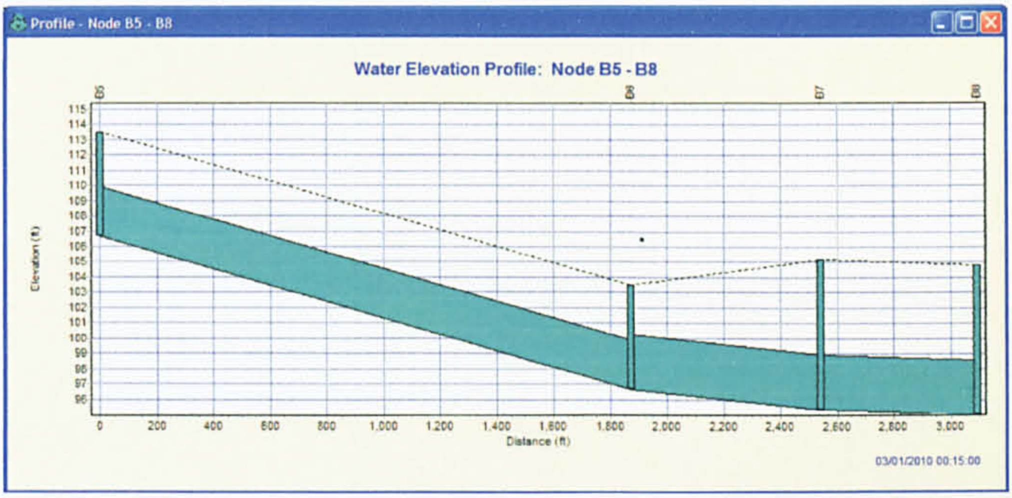

Figure 4.7 : Water Elevation Profile : Node B5 – B8

4.7 POND FLOODING

The status report shows that pond number 2 will be flooded. Since this project uses the updated plan of New Academic of UTP which is 2004, the actual area of the pond cannot be measure accurately. Basically, the ponds were connected to each other but in this plan; the pond was not connected, so that is the reasons why flooding might happened to pond number 2.

4.8 EVALUATION OF EPA SWMM WITH REFERENCES TO MSMA MANUAL

The objective of this project is to evaluate the performance and capabilities of the EPA SWMM with respect to meeting MSMA requirements. Generally, it is noticed that the design procedure that have applied in EPA SWMM is not exactly similar with MSMA practice in terms of discharge for pre-development and post-development.

In MSMA, it states that the discharge for pre-development is lower than post-development. This situation happened because the previous area of pre-development is large since the area is not yet developed. MSMA suggested designing pond as a function of storage, in order to reduce the discharge for post-development to make the discharge same as pre-development and to avoid that area from flooding. This situation shows that MSMA is being considered in both, the pre-development and post-development situations. In EPA SWMM, it only consider for the post-development. However, EPA SWMM considers the pervious and impervious area in the simulation which is also required in MSMA practices.

CHAPTER 5
ECONOMIC BENEFIT

Flash flood cause loss of lives, damage properties and buildings, and disturb human activities especially in the aspect of economic. To overcome these flash flood phenomena will cost a lot of money. There are many benefits can be obtain after apply the computer modeling which been used in this project. The runoff can be generates and control which can give beneficial for the long term durations.

The computer models give major advantage over manual calculation. They can perform task in a faster, more accurate design and allow better observation. Due to this accurate design, they can give cost saving by avoiding over sizing and under sizing the design. The users can estimate accurately regarding the estimation of a project that they involved, since they can adjust the parameter of the modeling until they achieve the satisfactory performance.

Besides that, the computer modeling can detect easily which nodes, conduits and ponds might be flooding during heavy rain. The occurrences of flash flood can prevent early since we can identify which areas have potential to be flooding and early action can be taken before they becoming more serious and required high cost to fix them.

CHAPTER 6

CONCLUSION AND RECOMMENDATION

As a conclusion, it has been shown that determination of runoff for post-development area can be achieved by using the computer models such as EPA SWMM. According to the simulation results, the analysis of drainage network is satisfactory due to identify which nodes and ponds have might be flooding. However, EPA SWMM has used different approaches of design and analysis compared to the MSMA manual practices.

In EPA SWMM, it only considers the discharge for post-development area but in MSMA practices, it being considered the discharge in both, the pre-development area and post-development area. Besides that, MSMA manual proposed Rational Method to compute peak runoff but in EPA SWMM, it can perform very well in Hydrograph method.

Due to these different approaches between EPA SWMM and MSMA, it will need some modifications on the EPA SWMM in order to suite the MSMA practices. For examples, EPA SWMM needs to consider the discharge for both, pre-development and post-development. Besides that, there is also limitation in linking the nodes or outfall. For nodes, they cannot have more than one outlet link while for outfall, it cannot have more than one inlet or outlet link.

All in all, the computer models are very important tool to help engineers perform their tasks faster, cheaper and better way. For software recommendation, the applications of inserting drawings such as subcatchments, sumps and conduits can be colour coded and not just black and white which is used in the current software. Colour coding can make user easier to differentiate the subcatchments, sumps and conduits.

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APPENDICES

APPENDIX 3.1 : Daily Rainfall Data from Rumah Pam Bota, Perak

APPENDIX 3.2 : Manning's n for Open Channels, Closed Conduit and Overland Flow

APPENDIX 3.3 : Manual Calculation by using Rational Method

APPENDIX 4.1 : Fitted Coefficients for IDF Curves for 35 Urban Centres

APPENDIX 4.2 : Design Temporal Patterns

APPENDIX 4.3 : Status Report (EPA SWMM)

APPENDIX 3.1 : Daily Rainfall Data from Rumah Pam Bota, Perak

Daily totals **Year 2009** **site 4309092 RUMAH PAM BOTA at PERAK**

Rain mm

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0	0	0	0	0	0	0	0	0	20.5	30.5	0	
2	0	0	19	13	15	0	0	0	0	8.5	0	0	
3	0	0	0	0	0	0	0	5	0	0	37.5	50	
4	12	0	0	15	5	0	0	0	22.5	25	0	0	
5	0	0	30	0	0	0	0	0	0	6	0	0	
6	0	0	15.5	0	0	0	5	0	0	0	30	0	
7	13	0	0	0	0	0	0	0	0	0	21	0	
8	0	0	0	0	0	0	0	0	0	0	0	0	
9	0	0	0	37.5	0	0	0	0	0	0	58	50	
10	0	0	0	12	0	0	0	0	0	5.5	0	0	
11	0	0	9	15	0	0	0	0	0	0	0	0	
12	0	0	15.5	0	8	0	0	0	25	4	50	0	
13	39	0	31.5	19	0	0	0	0	0	2	0	0	
14	0	0	0	0	0	0	0	5	0	0	86	40	
15	0	0	4.5	40	0	0	0	0	0	20	0	0	
16	21	7	0	0	48	0	0	0	35	16	4	0	
17	0	0	0	0	0	0	0	15	48.5	0	5	50	
18	0	0	0	0	0	0	0	6	15	0	8	0	
19	0	20	22	5	0	0	0	7	0	0	2	0	
20	0	0	0	0	0	0	48	11	0	0	34.5	0	
21	15	15	0	0	6	0	0	9	0	0	0	0	
22	0	0	0	0	0	0	0	0	0	0	0	0	
23	0	12.5	0	0	0	0	0	4	0	0	0	10	
24	13	7	50	0	0	64	0	0	0	53	0	0	
25	0	5	0	0	0	0	0	13.5	0	0	0	0	
26	0	0	0	0	0	0	0	31	0	0	0	50.5	
27	0	21	13	0	0	0	0	0	0	0	0	0	
28	0	27.5	0	0	4	0	0	8	72	0	30	0	
29	0		0	0	0	0	0	0	17	0	0	48	
30	0		0	0	0	0	0	0	0	0	0	0	
31	17		0		0		0	0		0		0	

Min	0	0	0	0	0	0	0	0	0	0	0	0	0
Tot	130	115	210	156.5	86	64	53	114.5	235	160.5	396.5	298.5	2019.5
Max	39	27.5	50	40	48	64	48	31	72	53	86	50.5	86
NO>0.0	7	8	10	8	6	1	2	11	7	10	13	7	90

APPENDIX 3.2 : Manning's n for Open Channels, Closed Conduit and Overland Flow

Manning's n – Open Channels

Channel Type	Manning n
Lined Channels	
- Asphalt	0.013 - 0.017
- Brick	0.012 - 0.018
- Concrete	0.011 - 0.020
- Rubble or riprap	0.020 - 0.035
- Vegetal	0.030 - 0.40
Excavated or dredged	
- Earth, straight and uniform	0.020 - 0.030
- Earth, winding, fairly uniform	0.025 - 0.040
- Rock	0.030 - 0.045
- Unmaintained	0.050 - 0.140
Natural channels (minor streams, top width at flood stage < 100 ft)	
- Fairly regular section	0.030 - 0.070
- Irregular section with pools	0.040 - 0.100

Manning's n – Closed Conduits

Conduit Material	Manning n
Asbestos-cement pipe	0.011 - 0.015
Brick	0.013 - 0.017
Cast iron pipe - Cement-lined & seal coated	 0.011 - 0.015
Concrete (monolithic) - Smooth forms - Rough forms	 0.012 - 0.014 0.015 - 0.017
Concrete pipe	0.011 - 0.015
Corrugated-metal pipe (1/2-in. x 2-2/3-in. corrugations) - Plain - Paved invert - Spun asphalt lined	 0.022 - 0.026 0.018 - 0.022 0.011 - 0.015
Plastic pipe (smooth)	0.011 - 0.015
Vitrified clay - Pipes - Liner plates	 0.011 - 0.015 0.013 - 0.017

Manning's n – Overland Flow

Surface	n
Smooth asphalt	0.011
Smooth concrete	0.012
Ordinary concrete lining	0.013
Good wood	0.014
Brick with cement mortar	0.014
Vitrified clay	0.015
Cast iron	0.015
Corrugated metal pipes	0.024
Cement rubble surface	0.024
Fallow soils (no residue)	0.05
Cultivated soils	
Residue cover < 20%	0.06
Residue cover > 20%	0.17
Range (natural)	0.13
Grass	
Short. prarie	0.15
Dense	0.24
Bermuda grass	0.41
Woods	
Light underbrush	0.40
Dense underbrush	0.80

APPENDIX 3.3 : Manual Calculation by using Rational Method

Manual Calculation by using Rational Method

Area	Catch. Area (ha)	Length of Overland (m)	n	slope %	to (min)	Length of Drain (m)	v (m/min)	td	tc (min)	Q (m^3/s)	Q link (m^3/s)	Drain Size (P.C Block + BS)	Design Slope	Drain Capacity (m^3/s)	Drain Velocity (m/s)
4.A	4.21	167.308	0.03	0.40	25.6365	155.25	64.5759	2.40415	28.0406	**0.943**		600mm BD	1:200	0.2583037	1.076266
4.B	0.57	34.178	0.03	0.30	17.4343	108.313	64.5759	1.6773	19.1116	**0.177**		600mm BD	1:200	0.2583037	1.076266
4.C	3.07	177.229	0.03	0.40	26.1335	131.099	71.2669	1.83955	27.9731	**0.672**		600mm x 400mm U-Drain	1:300	0.2850678	1.187782
4.D	0.46	37.746	0.03	0.40	15.6067	88.991	71.2669	1.2487	16.8554	**0.156**	**0.829**	600mm x 400mm U-Drain	1:300	0.2850678	1.187782
4.E	2.31	265.462	0.03	0.40	29.9011	104.357	71.2669	1.46431	31.3654	**0.471**		600mm x 400mm U-Drain	1:300	0.2850678	1.187782
4.F	2.04	54.608	0.03	0.40	17.6511	98.305	90.7758	1.08294	18.734	**0.639**	**1.939**	600mmBD / 800mm x 700mm	1:200	1.2103434	1.512929
4.G	2.79	111.888	0.03	0.40	22.4189	138.065	64.5759	2.13803	24.5569	**0.696**	**0.872**	600mm BD	1:200	0.2583037	1.076266
4.H	0.38	28.56	0.03	0.40	14.2213	66.9	64.5759	1.03599	15.2573	**0.141**		600mm BD	1:200	0.2583037	1.076266
4.I	13.39	343.737	0.03	0.40	32.5908	250.665	73.8195	3.39565	35.9865	**3.204**	**3.345**	600mmBD / 800mm x 300mm	1:200	0.5905556	1.230324
5.A	9.79	449.3	0.03	0.40	35.6341	111.515	116.869	0.95418	36.5882	**1.762**	**5.107**	1200mm x 900mm U-Drain	1:300	2.1036502	1.947824
5.B	16.27	313.02	0.03	0.40	31.59	251.80	73.82	3.41	35.00	**3.004**	**8.111**	600mmBD / 800mm x 300mm	1:200	0.5905556	1.2303
5.C	5.37	217.54	0.03	0.40	27.9813	131.503	83.3465	1.57779	29.5591	**1.141**	**9.252**	1200mm x 1050mm U-Drain	1:638	1.7502766	1.389108
5.D	3.72	103.07	0.03	0.40	21.8136	53.414	178.18	0.29978	22.1134	**1.032**	**10.284**	1500mm x 1500mm U-Drain	1:200	6.6817404	2.969662
6.B	10.31	165.657	0.03	0.30	29.5048	149.813	178.18	0.8408	30.3456	**2.155**	**12.440**	1500mm x 1500mm U-Drain	1:200	6.6817404	2.969662
7.A	6.02	391.994	0.03	4.00	10.7675	262.45	113.092	2.32068	13.0881	**2.474**	**4.413**	600mmBD / 1100mm x 1000mm	1:200	2.5257159	1.884863
7.C	1.42	105.456	0.03	0.30	25.3812	111.515	116.869	0.95418	26.3354	**0.335**		1200mm x 900mm U-Drain	1:300	2.1036502	1.947824
8.A	14.22	259.238	0.03	3.0	10.8323	300.09	79.8496	3.75819	14.5905	**5.286**	**8.247**	600mmBD / 600mm x 600mm	1:200	0.7984955	1.330826
8.B	1.58	54.211	0.03	0.4	17.6082	104.573	64.5759	1.61938	19.2276	**0.487**		600mm BD	1:200	0.2583037	1.076266
8.D	9.4	141.031	0.03	0.5	21.6606	456.712	139.373	3.27689	24.9375	**2.268**	**10.515**	600mmBD / 1700mm x 1100mm	1:200	4.9012999	2.322891
9.A	10.01	126.686	0.03	0.3	26.9815	286.361	64.5759	4.43448	31.4159	**2.020**		600mm BD	1:200	0.2583037	1.076266

9.B	3.55	63.588	0.03	0.3	21.4428	158.893	57.1851	2.77857	24.2213	**0.888**		500mmBD	1:200	0.1588476	0.953086
9.C	3	66.089	0.03	0.4	18.8103	137.684	64.5759	2.13213	20.9424	**0.866**		600mm BD	1:200	0.2583037	1.076266
9.D	19.26	249.247	0.03	0.3	33.809	286.36	197.243	1.45181	35.2608	**3.590**	**16.126**	1800mm x 1650mm U-Drain	1:200	9.7635489	3.28739
10.A	1.8	316.028	0.03	3.0	11.5717	240.955	81.2087	2.96711	14.5388	**0.673**		600mmBD / 900mm x 400mm	1:200	0.8120874	1.353479
10.B	2.7	102.229	0.03	0.3	25.1197	143.429	64.5759	2.22109	27.3408	**0.613**		600mm BD	1:200	0.2583037	1.076266
10.C	0.15	46.051	0.03	0.3	19.2561	168.953	81.2087	2.08048	21.3366	**0.043**		600mmBD / 900mm x 400mm	1:200	0.8120874	1.353479
10.D	0.11	88.943	0.03	0.3	23.9806	31.485	73.8195	0.42651	24.4071	**0.028**		600mmBD / 600mm x 400mm	1:200	0.5905556	1.230324
11.A	5.28	141.308	0.03	1.0	15.3263	114.631	197.243	0.58117	15.9075	**1.881**		1800mm x 1650mm U-Drain	1:200	9.7635489	3.28739
11.B	2.54	91.15	0.03	0.3	24.1773	151.345	64.5759	2.34367	26.521	**0.587**		600mm BD	1:200	0.2583037	1.076266
11.C	5.56	195.071	0.03	1.0	17.0653	74.67	64.5759	1.15631	18.2216	**1.796**		600mm BD	1:200	0.2583037	1.076266
11.D	1.43	93.901	0.03	0.3	24.4181	87.738	73.8195	1.18855	25.6067	**0.343**		600mmBD / 600mm x 400mm	1:200	0.5905556	1.230324
11.E(i)	0.63	47.423	0.03	0.1	33.6806	64.614	73.8195	0.8753	34.5559	**0.121**		600mmBD / 600mm x 400mm	1:200	0.5905556	1.230324
11.E(ii)	0.22	44.374	0.03	0.1	32.9427	14.43	81.2087	0.17769	33.1204	**0.043**		600mmBD / 900mm x 400mm	1:200	0.5905556	1.230324
11.F	8.47	381.409	0.03	3.0	12.3202	109.657	64.5759	1.69811	14.0184	**3.338**		600mm BD	1:200	0.2583037	1.076266
11.G	7.01	173.788	0.03	3.0	9.48045	163.109	57.1851	2.8523	12.3328	**2.955**		500mmBD	1:200	0.1588476	0.953086
11.H	4.84	179.851	0.03	0.3	30.3245	156.125	49.2807	3.16808	33.4926	**0.932**		400mmBD	1:200	0.0876103	0.821344

APPENDIX 4.1 : Fitted Coefficients for IDF Curves for 35 Urban Centres

APPENDIX 13.A FITTED COEFFICIENTS FOR IDF CURVES FOR 35 URBAN CENTRES

Table 13.A1 Coefficients for the IDF Equations for the Different Major Cities and Towns in Malaysia ($30 \leq t \leq 1000$ min)

State	Location	Data Period	ARI (year)	Coefficients of the IDF Polynomial Equations			
				a	b	c	d
Perlis	Kangar	1960-1983	2	4.6800	0.4719	-0.1915	0.0093
			5	5.7949	-0.1944	-0.0413	-0.0008
			10	6.5896	-0.6048	0.0445	-0.0064
			20	6.8710	-0.6670	0.0478	-0.0059
			50	7.1137	-0.7419	0.0621	-0.0067
			100	6.5715	-0.2462	-0.0518	0.0016
Kedah	Alor Setar	1951-1983	2	5.6790	-0.0276	-0.0993	0.0033
			5	4.9709	0.5460	-0.2176	0.0113
			10	5.6422	0.1575	-0.1329	0.0056
			20	5.8203	0.1093	-0.1248	0.0053
			50	5.7420	0.2273	-0.1481	0.0068
			100	6.3202	-0.0778	-0.0849	0.0026
Pulau Pinang	Penang	1951-1990	2	4.5140	0.6729	-0.2311	0.0118
			5	3.9599	1.1284	-0.3240	0.0180
			10	3.7277	1.4393	-0.4023	0.0241
			20	3.3255	1.7689	-0.4703	0.0286
			50	2.8429	2.1456	-0.5469	0.0335
			100	2.7512	2.2417	-0.5610	0.0341
Perak	Ipoh	1951-1990	2	5.2244	0.3853	-0.1970	0.0100
			5	5.0007	0.6149	-0.2406	0.0127
			10	5.0707	0.6515	-0.2522	0.0138
			20	5.1150	0.6895	-0.2631	0.0147
			50	4.9627	0.8489	-0.2966	0.0169
			100	5.1068	0.8168	-0.2905	0.0165
Perak	Bagan Serai	1960-1983	2	4.1689	0.8160	-0.2726	0.0149
			5	4.7867	0.4919	-0.1993	0.0099
			10	5.2760	0.2436	-0.1436	0.0059
			20	5.6661	0.0329	-0.0944	0.0024
			50	5.3431	0.3538	-0.1686	0.0078
			100	5.3299	0.4357	-0.1857	0.0089
Perak	Teluk Intan	1960-1983	2	5.6134	-0.1209	-0.0651	0.00004
			5	6.1025	-0.2240	-0.0484	-0.0008
			10	6.3160	-0.2756	-0.0390	-0.0012
			20	6.3504	-0.2498	-0.0377	-0.0016
			50	6.7638	-0.4595	0.0094	-0.0050
			100	6.7375	-0.3572	-0.0070	-0.0043
Perak	Kuala Kangsar	1960-1983	2	4.2114	0.9483	-0.3154	0.0179
			5	4.7986	0.5803	-0.2202	0.0107
			10	5.3916	0.2993	-0.1640	0.0071
			20	5.7854	0.1175	-0.1244	0.0044
			50	6.5736	-0.2903	-0.0482	0.00002
			100	6.0681	0.1478	-0.1435	0.0065
Perak	Setiawan	1951-1990	2	5.0790	0.3724	-0.1796	0.0081
			5	5.2320	0.3330	-0.1635	0.0068
			10	5.5868	0.0964	-0.1014	0.0021
			20	5.5294	0.2189	-0.1349	0.0051
			50	5.2993	0.4270	-0.1780	0.0082
			100	5.5575	0.3005	-0.1465	0.0058
Selangor	Kuala Kubu Bahru	1970-1990	2	4.2095	0.5056	-0.1551	0.0044
			5	5.1943	-0.0350	-0.0392	-0.0034
			10	5.5074	-0.1637	-0.0116	-0.0053
			20	5.6772	-0.1562	-0.0229	-0.0040
			50	6.0934	-0.3710	0.0239	-0.0073
			100	6.3094	-0.4087	0.0229	-0.0068

(Continued)

Table 13.A1 Coefficients for the IDF Equations for the Different Major Cities and Towns in Malaysia (30 ≤ t ≤ 1000 min)

State	Location	Data Period	ARI (year)	Coefficients of the IDF Polynomial Equations			
				a	b	c	d
Federal Territory	Kuala Lumpur	1953-1983	2	5.3255	0.1806	-0.1322	0.0047
			5	5.1086	0.5037	-0.2155	0.0112
			10	4.9696	0.6796	-0.2584	0.0147
			20	4.9781	0.7533	-0.2796	0.0166
			50	4.8047	0.9399	-0.3218	0.0197
			100	5.0064	0.8709	-0.3070	0.0186
Malacca	Malacca	1951-1990	2	3.7091	1.1622	-0.3289	0.0176
			5	4.3987	0.7725	-0.2381	0.0112
			10	4.9930	0.4661	-0.1740	0.0069
			20	5.0856	0.5048	-0.1875	0.0082
			50	4.8506	0.7398	-0.2388	0.0117
			100	5.3796	0.4628	-0.1826	0.0081
Negeri Sembilan	Seremban	1970-1990	2	5.2565	0.0719	-0.1306	0.0065
			5	5.4663	0.0586	-0.1269	0.0062
			10	6.1240	-0.2191	-0.0820	0.0039
			20	6.3733	-0.2451	-0.0888	0.0051
			50	6.9932	-0.5087	-0.0479	0.0031
			100	7.0782	-0.4277	-0.0731	0.0051
Negeri Sembilan	Kuala Pilah	1970-1990	2	3.9982	0.9722	-0.3215	0.0185
			5	3.7967	1.2904	-0.4012	0.0247
			10	4.5287	0.8474	-0.3008	0.0175
			20	4.9287	0.6897	-0.2753	0.0163
			50	4.7768	0.8716	-0.3158	0.0191
			100	4.6588	1.0163	-0.3471	0.0213
Johor	Kluang	1976-1990	2	4.5860	0.7083	-0.2761	0.0170
			5	5.0571	0.4815	-0.2220	0.0133
			10	5.2665	0.4284	-0.2131	0.0129
			20	5.4813	0.3471	-0.1945	0.0116
			50	5.8808	0.1412	-0.1498	0.0086
			100	6.3369	-0.0789	-0.1066	0.0059
Johor	Mersing	1951-1990	2	5.1028	0.2883	-0.1627	0.0095
			5	5.7048	-0.0635	-0.0771	0.0036
			10	5.8489	-0.0890	-0.0705	0.0032
			20	4.8420	0.7395	-0.2579	0.0165
			50	6.2257	-0.1499	-0.0631	0.0032
			100	6.7796	-0.4104	-0.0160	0.0005
Johor	Batu Pahat	1960-1983	2	4.5023	0.6159	-0.2289	0.0119
			5	4.9886	0.3883	-0.1769	0.0085
			10	5.2470	0.2916	-0.1575	0.0074
			20	5.7407	0.0204	-0.0979	0.0032
			50	6.2276	-0.2278	-0.0474	0.00002
			100	6.5443	-0.3840	-0.0135	-0.0022
Johor	Johor Bahru	1960-1983	2	3.8645	1.1150	-0.3272	0.0182
			5	4.3251	1.0147	-0.3308	0.0205
			10	4.4896	0.9971	-0.3279	0.0205
			20	4.7656	0.8922	-0.3060	0.0192
			50	4.5463	1.1612	-0.3758	0.0249
			100	5.0532	0.8998	-0.3222	0.0215
Johor	Segamat	1970-1983	2	3.0293	1.4428	-0.3924	0.0232
			5	4.2804	0.9393	-0.3161	0.0200
			10	6.2961	-0.1466	-0.1145	0.0080
			20	7.3616	-0.6982	-0.0131	0.0021
			50	7.4417	-0.6247	-0.0364	0.0041
			100	8.1159	-0.9379	0.0176	0.0013

(Continued)

Table 13.A1 Coefficients for the IDF Equations for the Different Major Cities and Towns in Malaysia (30 ≤ t ≤ 1000 min)

State	Location	Data Period	ARI (year)	Coefficients of the IDF Polynomial Equations			
				a	b	c	d
Pahang	Raub	1966-1983	2	4.3716	0.3725	-0.1274	0.0026
			5	4.5461	0.4017	-0.1348	0.0036
			10	5.4226	-0.1521	-0.0063	-0.0056
			20	5.2525	0.0125	-0.0371	-0.0035
			50	4.8654	0.3420	-0.1058	0.0012
			100	5.1818	0.2173	-0.0834	0.0001
Pahang	Cameron Highland	1951-1990	2	4.9396	0.2645	-0.1638	0.0082
			5	4.6471	0.4968	-0.2002	0.0099
			10	4.3258	0.7684	-0.2549	0.0134
			20	4.8178	0.5093	-0.2022	0.0100
			50	5.3234	0.2213	-0.1402	0.0059
			100	5.0166	0.4675	-0.1887	0.0089
Pahang	Kuantan	1951-1990	2	5.1899	0.2562	-0.1612	0.0096
			5	4.7566	0.6589	-0.2529	0.0167
			10	4.3754	0.9634	-0.3068	0.0198
			20	4.8517	0.7649	-0.2697	0.0176
			50	5.0350	0.7267	-0.2589	0.0167
			100	5.2158	0.6752	-0.2450	0.0155
Pahang	Temerloh	1970-1983	2	4.6023	0.4622	-0.1729	0.0066
			5	5.3044	0.0115	-0.0590	-0.0019
			10	4.5881	0.5465	-0.1646	0.0049
			20	4.4378	0.7118	-0.1960	0.0068
			50	4.4823	0.8403	-0.2288	0.0095
			100	4.5261	0.7210	-0.1988	0.0071
Terengganu	Kuala Dungun	1971-1983	2	5.2577	0.0572	-0.1091	0.0057
			5	5.5077	-0.0310	-0.0899	0.0050
			10	5.4881	0.0698	-0.1169	0.0074
			20	5.6842	-0.0393	-0.0862	0.0051
			50	5.5773	0.1111	-0.1231	0.0081
			100	6.1013	-0.1960	-0.0557	0.0035
Terengganu	Kuala Terengganu	1951-1983	2	4.6684	0.3966	-0.1700	0.0096
			5	4.4916	0.6583	-0.2292	0.0143
			10	5.2985	0.2024	-0.1380	0.0089
			20	5.8299	-0.0935	-0.0739	0.0046
			50	6.1694	-0.2513	-0.0382	0.0021
			100	6.1524	-0.1630	-0.0575	0.0035
Kelantan	Kota Bharu	1951-1990	2	5.4683	0.0499	-0.1171	0.0070
			5	5.7507	-0.0132	-0.1117	0.0078
			10	5.2497	0.4280	-0.2033	0.0139
			20	5.4724	0.3591	-0.1810	0.0119
			50	5.3578	0.5094	-0.2056	0.0131
			100	5.0646	0.7917	-0.2583	0.0161
Kelantan	Gua Musang	1971-1990	2	4.6132	0.6009	-0.2250	0.0114
			5	3.8834	1.2174	-0.3624	0.0213
			10	4.6080	0.8347	-0.2848	0.0161
			20	4.7584	0.7946	-0.2749	0.0154
			50	4.6406	0.9382	-0.3059	0.0176
			100	4.6734	0.9782	-0.3152	0.0183

(continued)

ɔle 13.A1 Coefficients for the IDF Equations for the Different Major Cities and Towns in Malaysia (30 ≤ t ≤ 1000 min)

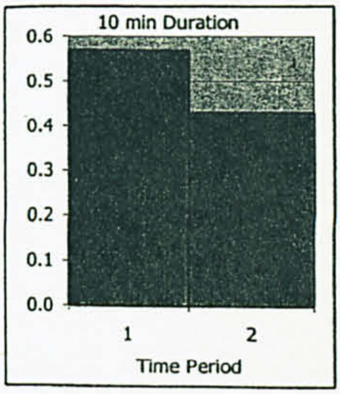
State	Location	Data Period	ARI (year)	Coefficients of the IDF Polynomial Equations			
				a	b	c	d
Sabah	Kota Kinabalu	1957-1980	2	5.1968	0.0414	-0.0712	-0.0002
			5	5.6093	-0.1034	-0.0359	-0.0027
			10	5.9468	-0.2595	-0.0012	-0.0050
			20	5.2150	0.3033	-0.1164	0.0026
			50	5.1922	0.3652	-0.1224	0.0027
Sabah	Sandakan	1957-1980	2	3.7427	1.2253	-0.3396	0.0191
			5	4.9246	0.5151	-0.1886	0.0095
			10	5.2728	0.3693	-0.1624	0.0083
			20	4.9397	0.6675	-0.2292	0.0133
			50	5.0022	0.6587	-0.2195	0.0123
Sabah	Tawau	1966-1978	2	4.1091	0.6758	-0.2122	0.0093
			5	3.1066	1.7041	-0.4717	0.0298
			10	4.1419	1.1244	-0.3517	0.0220
			20	4.4639	1.0439	-0.3427	0.0220
Sabah	Kuamut	1969-1980	2	4.1878	0.9320	-0.3115	0.0183
			5	3.7522	1.3976	-0.4086	0.0249
			10	4.1594	1.2539	-0.3837	0.0236
			20	3.8422	1.5659	-0.4505	0.0282
			50	5.6274	0.3053	-0.1644	0.0079
			100	6.3202	-0.0778	-0.0849	0.0026
Sarawak	Simanggang	1963-1980	2	4.3333	0.7773	-0.2644	0.0144
			5	4.9834	0.4624	-0.1985	0.0100
			10	5.6753	0.0623	-0.1097	0.0038
			20	5.9006	-0.0189	-0.0922	0.0027
Sarawak	Sibu	1962-1980	2	3.0879	1.6430	-0.4472	0.0262
			5	3.4519	1.4161	-0.3754	0.0200
			10	3.6423	1.3388	-0.3509	0.0177
			20	3.3170	1.5906	-0.3955	0.0202
Sarawak	Bintulu	1953-1980	2	5.2707	0.1314	-0.0976	0.0025
			5	5.5722	0.0563	-0.0919	0.0031
			10	6.1060	-0.2520	-0.0253	-0.0012
			20	6.0081	-0.1173	-0.0574	0.0014
			50	6.2652	-0.2584	-0.0244	-0.0008
Sarawak	Kapit	1964-1974	2	3.2235	1.2714	-0.3268	0.0164
			5	4.5416	0.2745	-0.0700	-0.0032
			10	4.5184	0.2886	-0.0600	-0.0045
			20	5.0785	-0.0820	0.0296	-0.0110
Sarawak	Kuching	1951-1980	2	5.1719	0.1558	-0.1093	0.0043
			5	4.8825	0.3871	-0.1455	0.0068
			10	5.1635	0.2268	-0.1039	0.0039
			20	5.2479	0.2107	-0.0968	0.0035
			50	5.2780	0.2240	-0.0932	0.0031
Sarawak	Miri	1953-1980	2	4.9302	0.2564	-0.1240	0.0038
			5	5.8216	-0.2152	-0.0276	-0.0021
			10	6.1841	-0.3856	0.0114	-0.0048
			20	6.1591	-0.3188	0.0021	-0.0044
			50	6.3582	-0.3823	0.0170	-0.0054

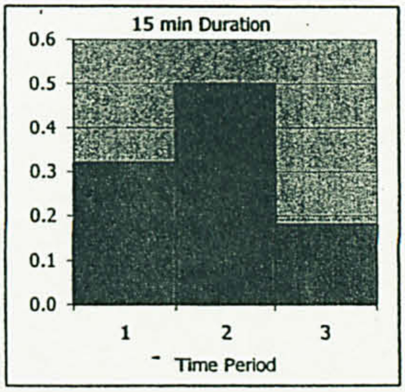
APPENDIX 4.2 : Design Temporal Patterns

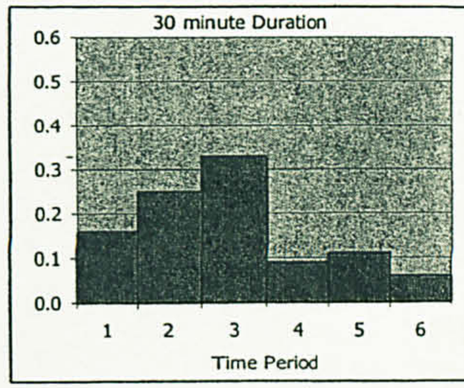
APPENDIX 13.B DESIGN TEMPORAL PATTERNS

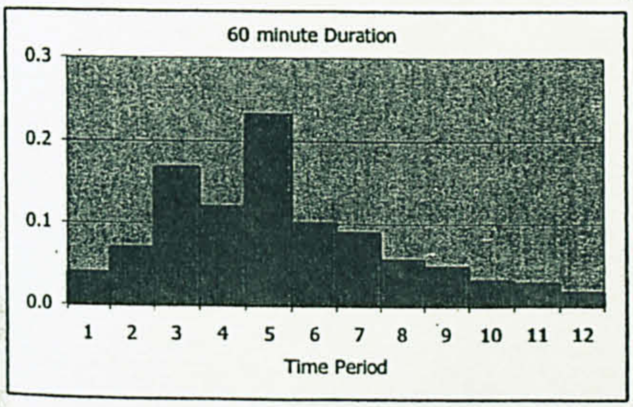
Table 13.B1 Temporal Patterns – West Coast of Peninsular Malaysia

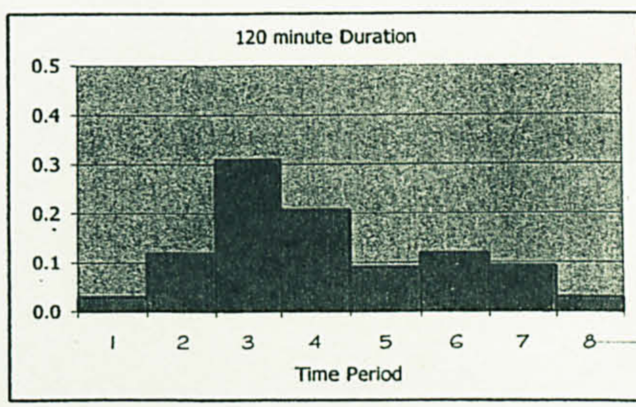
Duration (min)	No. of Time Periods	Fraction of Rainfall in Each Time Period											
10	2	0.570	0.430	-	-	-	-	-	-	-	-	-	-
15	3	0.320	0.500	0.180	-	-	-	-	-	-	-	-	-
30	6	0.160	0.250	0.330	0.090	0.110	0.060	-	-	-	-	-	-
60	12	0.039	0.070	0.168	0.120	0.232	0.101	0.089	0.057	0.048	0.031	0.028	0.017
120	8	0.030	0.119	0.310	0.208	0.090	0.119	0.094	0.030	-	-	-	-
180	6	0.060	0.220	0.340	0.220	0.120	0.040	-	-	-	-	-	-
360	6	0.320	0.410	0.110	0.080	0.050	0.030	-	-	-	-	-	-

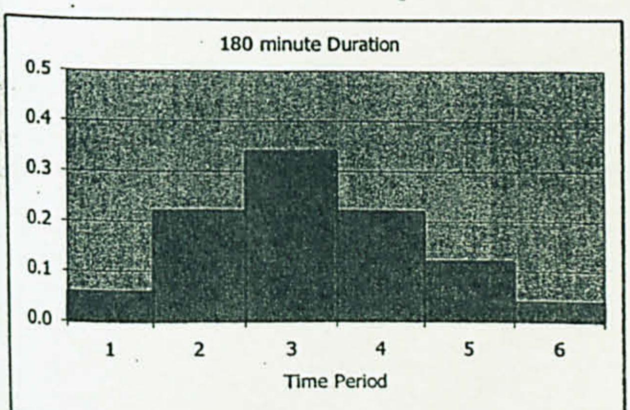


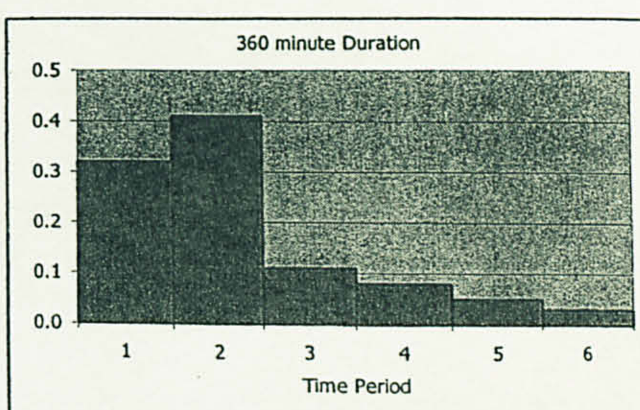












APPENDIX 4.3 : Status Report (EPA SWMM)

STATUS REPORT (EPA SWMM)

BY USING TIME SERIES 1

************************** Runoff Quantity Continuity **************************	Volume acre-feet	Depth inches
Total Precipitation	146.222	2.459
Evaporation Loss	0.000	0.000
Infiltration Loss	77.848	1.309
Surface Runoff	67.016	1.127
Final Surface Storage	1.350	0.023
Continuity Error (%)	0.006	

************************** Flow Routing Continuity **************************	Volume acre-feet	Volume 10^6 gal
Dry Weather Inflow	0.000	0.000
Wet Weather Inflow	66.994	21.831
Groundwater Inflow	0.000	0.000
RDII Inflow	0.000	0.000
External Inflow	0.000	0.000
External Outflow	66.186	21.568
Internal Outflow	0.805	0.262
Storage Losses	0.000	0.000
Initial Stored Volume	0.000	0.000
Final Stored Volume	0.006	0.002
Continuity Error (%)	-0.006	

****
Highest Flow Instability Indexes
****
All links are stable.

****
Routing Time Step Summary
****

Minimum Time Step	:	30.00 sec
Average Time Step	:	30.00 sec
Maximum Time Step	:	30.00 sec
Percent in Steady State	:	0.00
Average Iterations per Step	:	1.00

****
Subcatchment Runoff Summary
****

Subcatchment	Total Precip in	Total Runon in	Total Evap in	Total Infil in	Total Runoff in	Total Runoff 10^6 gal	Peak Runoff CFS	Runoff Coeff
S4(3)	2.459	0.000	0.000	2.336	0.121	0.432	0.239	0.049
S4(4)	2.459	0.000	0.000	2.336	0.115	0.001	0.001	0.047
S4(5)	2.459	0.000	0.000	1.475	0.966	0.025	0.014	0.393
S4(6)	2.459	0.000	0.000	1.475	0.965	0.047	0.026	0.392
S4(7)	2.459	0.000	0.000	0.492	1.928	0.126	0.070	0.784
S4(8)	2.459	0.000	0.000	0.492	1.928	0.154	0.086	0.784
S4(9)	2.459	0.000	0.000	1.475	0.964	0.135	0.075	0.392
S4(10)	2.459	0.000	0.000	1.230	1.206	0.035	0.020	0.490
S4(11)	2.459	0.000	0.000	0.984	1.447	0.044	0.024	0.588
S4(12)	2.459	0.000	0.000	0.984	1.447	0.045	0.025	0.588
S4(13)	2.459	0.000	0.000	0.984	1.447	0.004	0.002	0.589
S4(14)	2.459	0.000	0.000	1.475	0.965	0.015	0.008	0.392
S4(15)	2.459	0.000	0.000	1.475	0.965	0.025	0.014	0.392
S4(16)	2.459	0.000	0.000	0.738	1.688	0.050	0.028	0.686
S4(17)	2.459	0.000	0.000	0.984	1.447	0.018	0.010	0.588
S4(18)	2.459	0.000	0.000	1.230	1.206	0.064	0.035	0.490
S4(19)	2.459	0.000	0.000	1.230	1.207	0.007	0.004	0.491
S4(20)	2.459	0.000	0.000	0.369	2.049	0.234	0.130	0.833
S4(21)	2.459	0.000	0.000	0.246	2.169	0.154	0.085	0.882
S4(22)	2.459	0.000	0.000	1.475	0.965	0.015	0.009	0.392

S4(23)	2.459	0.000	0.000	0.492	1.928	0.034	0.019	0.784
S4(24)	2.459	0.000	0.000	1.475	0.965	0.014	0.008	0.392
S4(25)	2.459	0.000	0.000	0.492	1.929	0.020	0.011	0.784
S4(26)	2.459	0.000	0.000	0.492	1.929	0.022	0.012	0.784
S4(27)	2.459	0.000	0.000	0.984	1.446	0.462	0.256	0.588
S4(28)	2.459	0.000	0.000	1.475	0.964	0.328	0.182	0.392
S4(29)	2.459	0.000	0.000	1.230	1.205	0.153	0.085	0.490
S5(1)	2.459	0.000	0.000	1.967	0.482	0.252	0.139	0.196
S5(2)	2.459	0.000	0.000	1.967	0.482	0.128	0.071	0.196
S5(3)	2.459	0.000	0.000	0.246	2.169	0.529	0.294	0.882
S5(4)	2.459	0.000	0.000	1.967	0.482	0.194	0.107	0.196
S5(5)	2.459	0.000	0.000	0.246	2.169	0.394	0.219	0.882
S5(6)	2.459	0.000	0.000	0.492	1.928	0.291	0.161	0.784
S5(7)	2.459	0.000	0.000	0.246	2.169	1.054	0.585	0.882
S6(1)	2.459	0.000	0.000	0.369	2.050	0.061	0.034	0.834
S6(2)	2.459	0.000	0.000	0.369	2.049	0.526	0.292	0.833
S6(3)	2.459	0.000	0.000	0.369	2.048	0.959	0.532	0.833
S6(4)	2.459	0.000	0.000	0.246	2.169	0.594	0.329	0.882
S6(5)	2.459	0.000	0.000	0.246	2.168	1.212	0.672	0.882
S7(1)	2.459	0.000	0.000	1.967	0.482	0.579	0.321	0.196
S7(2)	2.459	0.000	0.000	1.967	0.483	0.104	0.058	0.196
S7(3)	2.459	0.000	0.000	0.492	1.929	0.555	0.308	0.784
S7(4)	2.459	0.000	0.000	0.246	2.170	0.144	0.080	0.882
S7(5)	2.459	0.000	0.000	0.246	2.169	0.483	0.268	0.882
S8(1)	2.459	0.000	0.000	1.967	0.483	0.203	0.113	0.196
S8(2)	2.459	0.000	0.000	1.967	0.483	0.118	0.065	0.196
S8(3)	2.459	0.000	0.000	0.492	1.928	0.243	0.135	0.784
S8(4)	2.459	0.000	0.000	0.246	2.169	0.618	0.343	0.882
S8(5)	2.459	0.000	0.000	1.230	1.206	0.026	0.015	0.490
S8(6)	2.459	0.000	0.000	1.230	1.205	0.030	0.017	0.490
S8(7)	2.459	0.000	0.000	0.738	1.688	0.042	0.023	0.687
S8(8)	2.459	0.000	0.000	1.230	1.205	0.114	0.063	0.490
S8(11)	2.459	0.000	0.000	1.230	1.205	0.313	0.174	0.490
S8(12)	2.459	0.000	0.000	0.246	2.169	0.648	0.360	0.882
S9(1)	2.459	0.000	0.000	0.246	2.169	0.713	0.395	0.882
S9(2)	2.459	0.000	0.000	0.246	2.169	1.734	0.962	0.882
S9(3)	2.459	0.000	0.000	0.246	2.170	0.134	0.074	0.883
S9(4)	2.459	0.000	0.000	0.246	2.170	0.041	0.023	0.882
S9(5)	2.459	0.000	0.000	0.246	2.169	0.009	0.005	0.882
S9(6)	2.459	0.000	0.000	0.246	2.169	0.008	0.005	0.882
S9(7)	2.459	0.000	0.000	0.246	2.170	0.021	0.011	0.882
S9(8)	2.459	0.000	0.000	0.246	2.169	0.164	0.091	0.882
S9(9)	2.459	0.000	0.000	0.246	2.170	0.058	0.032	0.882
S9(10)	2.459	0.000	0.000	0.246	2.169	0.100	0.055	0.882
S9(11)	2.459	0.000	0.000	0.246	2.170	0.018	0.010	0.882
S9(12)	2.459	0.000	0.000	0.246	2.169	0.209	0.116	0.882
S9(13)	2.459	0.000	0.000	0.246	2.169	0.262	0.145	0.882
S9(14)	2.459	0.000	0.000	0.246	2.169	0.231	0.128	0.882
S9(15)	2.459	0.000	0.000	0.246	2.170	0.087	0.048	0.882
S9(16)	2.459	0.000	0.000	0.984	1.446	0.274	0.152	0.588
S9(17)	2.459	0.000	0.000	0.984	1.446	0.085	0.047	0.588
S9(18)	2.459	0.000	0.000	1.230	1.206	0.078	0.043	0.490
S9(19)	2.459	0.000	0.000	1.230	1.205	0.144	0.080	0.490
S10(2)	2.459	0.000	0.000	0.246	2.169	1.023	0.568	0.882
S10(3)	2.459	0.000	0.000	0.246	2.170	0.085	0.047	0.882
S10(4)	2.459	0.000	0.000	0.246	2.170	0.019	0.010	0.883
S10(5)	2.459	0.000	0.000	0.246	2.170	0.016	0.009	0.883
S10(6)	2.459	0.000	0.000	0.984	1.446	0.246	0.136	0.588
S10(7)	2.459	0.000	0.000	0.984	1.446	0.142	0.079	0.588
S10(8)	2.459	0.000	0.000	0.984	1.447	0.040	0.022	0.588
S10(9)	2.459	0.000	0.000	0.246	2.169	1.197	0.664	0.882
S10(10)	2.459	0.000	0.000	0.984	1.447	0.048	0.026	0.589
S10(11)	2.459	0.000	0.000	1.230	1.206	0.039	0.022	0.490
S10(12)	2.459	0.000	0.000	1.230	1.147	0.018	0.013	0.466
S10(13)	2.459	0.000	0.000	1.230	1.206	0.039	0.022	0.490
S10(14)	2.459	0.000	0.000	1.230	1.206	0.018	0.010	0.491
S10(15)	2.459	0.000	0.000	2.213	0.241	0.125	0.069	0.098
S10(16)	2.459	0.000	0.000	2.213	0.229	0.016	0.011	0.093
S11(1)	2.459	0.000	0.000	0.984	1.447	0.284	0.157	0.588
S11(2)	2.459	0.000	0.000	0.984	1.446	0.119	0.066	0.588
S11(3)	2.459	0.000	0.000	1.230	1.206	0.022	0.012	0.490
S11(4)	2.459	0.000	0.000	1.230	1.205	0.019	0.011	0.490

S11(5)	2.459	0.000	0.000	1.230	1.206	0.030	0.017	0.490
S11(6)	2.459	0.000	0.000	1.230	1.205	0.146	0.081	0.490
S11(7)	2.459	0.000	0.000	1.230	1.206	0.009	0.005	0.490
S11(8)	2.459	0.000	0.000	1.230	1.206	0.009	0.005	0.490
S11(9)	2.459	0.000	0.000	2.213	0.241	0.041	0.023	0.098
S11(10)	2.459	0.000	0.000	1.230	1.205	0.047	0.026	0.490
S11(11)	2.459	0.000	0.000	1.230	1.206	0.027	0.015	0.490
S11(12)	2.459	0.000	0.000	1.230	1.205	0.021	0.012	0.490
S11(13)	2.459	0.000	0.000	2.213	0.241	0.094	0.052	0.098
S11(14)	2.459	0.000	0.000	2.213	0.241	0.108	0.060	0.098
S11(15)	2.459	0.000	0.000	1.721	0.723	0.016	0.009	0.294
S11(16)	2.459	0.000	0.000	1.721	0.723	0.018	0.010	0.294
S11(17)	2.459	0.000	0.000	1.967	0.482	0.144	0.080	0.196
S11(18)	2.459	0.000	0.000	1.967	0.482	0.166	0.092	0.196
System	2.459	0.000	0.000	1.309	1.127	21.836	12.113	0.458

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Node Depth Summary
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Node	Type	Average Depth Feet	Maximum Depth Feet	Maximum HGL Feet	Time of Max Occurrence days	hr:min
OA	JUNCTION	0.00	0.00	129.33	0	00:00
A	JUNCTION	0.02	0.04	123.27	3	21:32
A1	JUNCTION	0.08	0.18	122.88	3	21:32
OA2	JUNCTION	0.00	0.00	129.53	0	00:00
A2	JUNCTION	0.14	0.30	120.74	3	21:34
A3	JUNCTION	0.14	0.30	120.64	3	20:35
B	JUNCTION	0.03	0.07	127.36	3	20:58
B1	JUNCTION	0.00	0.00	119.98	0	00:00
B2	JUNCTION	0.00	0.00	117.69	0	00:00
B3	JUNCTION	0.00	0.00	113.19	0	00:00
B31	JUNCTION	0.02	0.04	99.63	3	19:17
B4	JUNCTION	0.05	0.11	107.72	3	12:59
B5	JUNCTION	0.13	0.27	106.93	3	20:40
B6	JUNCTION	0.26	0.57	97.22	3	20:03
B61	JUNCTION	0.00	0.00	97.47	0	00:00
B7	JUNCTION	0.36	0.79	96.13	4	00:01
B8	JUNCTION	0.36	0.79	95.80	4	00:04
C	JUNCTION	0.08	0.17	127.14	3	21:27
C1	JUNCTION	0.08	0.17	118.61	4	00:01
C2	JUNCTION	0.10	0.22	116.36	4	00:01
C3	JUNCTION	0.10	0.22	114.89	4	00:01
C5	JUNCTION	0.14	0.31	100.08	3	03:15
C6	JUNCTION	0.14	0.31	99.75	3	21:03
C7	JUNCTION	0.15	0.32	98.75	3	20:05
C8	JUNCTION	0.21	0.44	98.01	3	20:22
C9	JUNCTION	0.21	0.44	96.63	4	00:01
C91	JUNCTION	5.82	6.89	35.73	1	00:03
C10	JUNCTION	0.00	0.00	98.81	0	00:00
OD	JUNCTION	0.00	0.00	98.49	0	00:00
D	JUNCTION	0.13	0.27	98.37	3	23:31
D1	JUNCTION	0.14	0.30	97.28	4	00:00
D2	JUNCTION	0.14	0.30	96.56	4	00:02
D3	JUNCTION	0.18	0.39	96.19	4	00:00
D4	JUNCTION	0.21	0.44	94.08	3	23:59
D5	JUNCTION	0.22	0.46	91.08	3	02:18
D6	JUNCTION	0.28	0.59	87.34	4	00:00
D7	JUNCTION	0.28	0.59	86.73	4	00:00
D8	JUNCTION	0.23	0.48	85.12	4	00:00
D9	JUNCTION	0.21	0.44	83.96	4	00:00
D10	JUNCTION	0.18	0.39	79.95	3	16:50
F	JUNCTION	0.00	0.00	132.48	0	00:00
F1	JUNCTION	0.08	0.18	99.10	3	18:18
OF11	JUNCTION	0.00	0.00	135.46	0	00:00
F11	JUNCTION	0.02	0.04	99.12	3	18:57
G	JUNCTION	0.37	0.80	95.62	3	22:13

G1	JUNCTION	0.38	0.82	94.36	4	00:02
G2	JUNCTION	0.51	1.08	94.03	4	00:00
G3	JUNCTION	0.51	1.08	93.40	4	00:01
G4	JUNCTION	0.19	0.45	92.48	4	00:00
G5	JUNCTION	0.18	0.44	91.98	4	00:02
G6	JUNCTION	0.18	0.44	91.38	4	00:05
G7	JUNCTION	0.16	0.38	91.00	4	00:05
G8	JUNCTION	0.11	0.28	90.57	4	00:06
OH	JUNCTION	0.05	0.10	116.33	3	13:34
H	JUNCTION	0.05	0.10	103.85	4	00:00
OH1	JUNCTION	0.04	0.08	115.29	3	13:48
H1	JUNCTION	0.13	0.29	103.94	3	23:37
H2	JUNCTION	0.17	0.36	98.20	4	00:01
H3	JUNCTION	0.07	0.15	127.54	3	20:01
H4	JUNCTION	0.17	0.36	99.86	3	21:03
H5	JUNCTION	0.08	0.19	97.86	4	00:02
OI	JUNCTION	0.00	0.00	130.30	0	00:00
I	JUNCTION	0.03	0.06	117.67	3	22:13
I1	JUNCTION	0.16	0.34	117.43	4	00:00
I2	JUNCTION	0.16	0.35	115.52	4	00:07
I3	JUNCTION	0.06	0.13	100.95	3	21:30
I4	JUNCTION	0.18	0.38	100.93	4	00:00
I5	JUNCTION	0.18	0.38	81.77	4	00:00
I6	JUNCTION	0.00	0.00	84.95	0	00:00
OJ	JUNCTION	0.07	0.16	132.52	3	16:32
J1	JUNCTION	0.10	0.22	116.15	3	15:34
OJ1	JUNCTION	0.09	0.20	120.82	3	14:35
J2	JUNCTION	0.26	0.56	116.23	3	15:31
OJ2	JUNCTION	0.06	0.13	127.44	3	14:30
J3	JUNCTION	0.26	0.56	115.72	4	00:04
J4	JUNCTION	0.14	0.30	102.66	3	15:18
J5	JUNCTION	0.14	0.30	101.08	4	00:00
J6	JUNCTION	0.15	0.35	80.34	4	00:02
J7	JUNCTION	0.13	0.31	80.00	3	16:50
K	JUNCTION	0.02	0.05	114.96	3	15:19
K1	JUNCTION	0.15	0.37	81.34	4	00:00
K2	JUNCTION	0.16	0.38	80.92	4	00:00
K3	JUNCTION	0.16	0.38	80.69	4	00:01
M	JUNCTION	0.00	0.00	127.15	0	00:00
M1	JUNCTION	0.01	0.02	130.22	3	06:19
J92	JUNCTION	0.15	0.33	79.89	4	00:00
J93	JUNCTION	0.00	0.00	127.29	0	00:00
J94	JUNCTION	0.00	0.00	113.19	0	00:00
J95	JUNCTION	0.00	0.00	114.67	0	00:00
J96	JUNCTION	0.00	0.00	115.17	0	00:00
J97	JUNCTION	0.00	0.00	100.78	0	00:00
J98	JUNCTION	0.00	0.00	114.91	0	00:00
J99	JUNCTION	0.00	0.00	19.69	0	00:00
Out1	OUTFALL	0.18	0.39	0.39	3	16:50
2	STORAGE	6.06	49.21	74.73	3	15:11
3	STORAGE	0.14	0.30	24.25	4	18:24

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Node InFlow Summary
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Node	Type	Maximum Lateral Inflow CFS	Maximum Total Inflow CFS	Time of Max Occurrence days	hr:min	Lateral Inflow Volume 10^6 gal	Total Inflow Volume 10^6 gal
OA	JUNCTION	0.00	0.00	0	00:00	0.000	0.000
A	JUNCTION	0.10	0.10	3	21:47	0.174	0.174
A1	JUNCTION	0.02	0.12	3	21:32	0.035	0.209
OA2	JUNCTION	0.00	0.00	0	00:00	0.000	0.000
A2	JUNCTION	0.18	0.30	3	21:34	0.333	0.542
A3	JUNCTION	0.01	0.31	3	20:35	0.015	0.557
B	JUNCTION	0.28	0.28	3	21:26	0.510	0.512
B1	JUNCTION	0.00	0.00	0	00:00	0.000	0.000
B2	JUNCTION	0.00	0.00	0	00:00	0.000	0.000

B3	JUNCTION	0.00	0.00	0	00:00	0.000	0.000
B31	JUNCTION	0.15	0.15	3	19:25	0.268	0.268
B4	JUNCTION	0.03	0.03	3	12:59	0.057	0.057
B5	JUNCTION	0.05	0.39	3	20:40	0.091	0.705
B6	JUNCTION	0.77	1.16	3	21:02	1.381	2.087
B61	JUNCTION	0.00	0.00	0	00:00	0.000	0.000
B7	JUNCTION	0.07	1.23	4	00:01	0.118	2.205
B8	JUNCTION	0.16	1.59	3	19:32	0.285	2.863
C	JUNCTION	0.02	0.31	3	21:27	0.038	0.550
C1	JUNCTION	0.00	0.31	4	00:01	0.000	0.550
C2	JUNCTION	0.00	0.31	4	00:01	0.000	0.550
C3	JUNCTION	0.00	0.31	4	00:01	0.000	0.550
C5	JUNCTION	0.27	0.57	3	21:03	0.482	1.031
C6	JUNCTION	0.00	0.57	3	21:31	0.000	1.031
C7	JUNCTION	0.19	0.92	3	20:05	0.350	1.649
C8	JUNCTION	0.17	1.09	3	20:22	0.307	1.956
C9	JUNCTION	0.41	1.49	3	20:18	0.734	2.691
C91	JUNCTION	0.00	1.49	3	21:18	0.000	2.691
C10	JUNCTION	0.00	0.00	0	00:00	0.000	0.000
OD	JUNCTION	0.00	0.00	0	00:00	0.000	0.000
D	JUNCTION	0.36	0.36	3	23:31	0.657	0.657
D1	JUNCTION	0.11	0.47	4	00:00	0.194	0.851
D2	JUNCTION	0.22	0.69	4	00:00	0.394	1.244
D3	JUNCTION	0.16	0.85	4	00:00	0.291	1.536
D4	JUNCTION	0.62	1.47	3	23:59	1.115	2.650
D5	JUNCTION	1.83	3.30	4	00:00	3.290	5.940
D6	JUNCTION	0.66	3.96	4	00:00	1.197	7.137
D7	JUNCTION	0.00	3.96	4	00:00	0.000	7.137
D8	JUNCTION	0.00	3.96	4	00:00	0.000	7.137
D9	JUNCTION	0.00	3.96	4	00:00	0.000	7.137
D10	JUNCTION	0.00	6.66	3	16:50	0.000	12.001
F	JUNCTION	0.00	0.00	0	00:00	0.000	0.000
F1	JUNCTION	0.13	0.21	3	18:58	0.229	0.374
OF11	JUNCTION	0.00	0.00	0	00:00	0.000	0.000
F11	JUNCTION	0.08	0.08	3	19:03	0.144	0.144
G	JUNCTION	0.53	2.12	3	22:47	0.961	3.825
G1	JUNCTION	0.37	2.49	4	00:02	0.659	4.484
G2	JUNCTION	0.40	3.60	4	00:00	0.722	6.488
G3	JUNCTION	1.12	4.72	4	00:00	2.025	8.513
G4	JUNCTION	0.00	4.72	4	00:00	0.000	8.513
G5	JUNCTION	0.00	4.72	4	00:02	0.000	8.513
G6	JUNCTION	0.00	4.73	4	00:05	0.000	8.513
G7	JUNCTION	0.00	4.73	4	00:05	0.000	8.513
G8	JUNCTION	0.00	4.73	4	00:06	0.000	8.512
OH	JUNCTION	0.09	0.09	3	13:34	0.154	0.154
H	JUNCTION	0.00	0.09	4	00:00	0.000	0.154
OH1	JUNCTION	0.06	0.06	3	13:48	0.105	0.105
H1	JUNCTION	0.18	0.33	3	23:50	0.330	0.589
H2	JUNCTION	0.00	0.71	4	00:01	0.000	1.281
H3	JUNCTION	0.21	0.21	3	20:19	0.372	0.372
H4	JUNCTION	0.18	0.38	3	21:13	0.320	0.692
H5	JUNCTION	0.00	0.71	4	00:02	0.000	1.281
OI	JUNCTION	0.00	0.00	0	00:00	0.000	0.000
I	JUNCTION	0.20	0.20	3	22:26	0.359	0.359
I1	JUNCTION	0.00	0.20	4	00:00	0.000	0.359
I2	JUNCTION	0.19	0.38	3	21:30	0.334	0.693
I3	JUNCTION	0.06	0.44	3	21:31	0.104	0.797
I4	JUNCTION	0.74	1.18	4	00:00	1.326	2.123
I5	JUNCTION	0.00	1.18	4	00:00	0.000	2.123
I6	JUNCTION	0.00	0.00	0	00:00	0.000	0.000
OJ	JUNCTION	0.12	0.12	3	16:32	0.222	0.222
J1	JUNCTION	0.11	0.32	3	16:01	0.193	0.577
OJ1	JUNCTION	0.09	0.09	3	14:35	0.162	0.162
J2	JUNCTION	0.05	0.44	3	16:01	0.094	0.794
OJ2	JUNCTION	0.07	0.07	3	14:30	0.123	0.123
J3	JUNCTION	0.04	0.48	3	15:17	0.070	0.864
J4	JUNCTION	0.09	0.57	3	15:18	0.164	1.028
J5	JUNCTION	0.01	0.58	4	00:00	0.016	1.043
J6	JUNCTION	0.01	6.66	3	16:49	0.018	12.002
J7	JUNCTION	0.00	6.66	3	16:50	0.000	12.001
K	JUNCTION	0.03	0.03	3	15:19	0.058	0.058
K1	JUNCTION	0.10	6.03	4	00:00	0.181	10.875

K2	JUNCTION	0.03	6.06	4	00:00	0.048	10.922
K3	JUNCTION	0.01	6.07	3	18:15	0.018	10.940
M	JUNCTION	0.00	0.00	0	00:00	0.000	0.000
M1	JUNCTION	0.00	0.00	3	06:19	0.001	0.001
J92	JUNCTION	0.00	3.96	4	00:00	0.000	7.137
J93	JUNCTION	0.00	0.00	0	00:00	0.000	0.000
J94	JUNCTION	0.00	0.00	0	00:00	0.000	0.000
J95	JUNCTION	0.00	0.00	0	00:00	0.000	0.000
J96	JUNCTION	0.00	0.00	0	00:00	0.000	0.000
J97	JUNCTION	0.00	0.00	0	00:00	0.000	0.000
J98	JUNCTION	0.00	0.00	0	00:00	0.000	0.000
J99	JUNCTION	0.00	3.03	4	18:24	0.000	6.874
Out1	OUTFALL	0.00	6.66	3	16:50	0.000	12.001
2	STORAGE	0.00	3.96	4	00:00	0.000	7.137
3	STORAGE	0.00	3.13	4	18:23	0.000	6.874

****
Node Surcharge Summary
****

Surcharging occurs when water rises above the top of the highest conduit.

Node	Type	Hours Surcharged	Max. Height Above Crown Feet	Min. Depth Below Rim Feet
C91	JUNCTION	182.58	4.920	0.000
2	STORAGE	40.48	48.210	0.000

****
Node Flooding Summary
****

Flooding refers to all water that overflows a node, whether it ponds or not.

Node	Hours Flooded	Maximum Rate CFS	Time of Max Occurrence days hr:min	Total Flood Volume 10^6 gal	Maximum Ponded Volume acre-in
C91	182.58	0.00	0 00:00	0.000	0.00
2	9.62	1.06	4 00:00	0.262	0.00

****
Storage Volume Summary
****

Storage Unit	Average Volume 1000 ft3	Avg Pcnt Full	Maximum Volume 1000 ft3	Max Pcnt Full	Time of Max Occurrence days hr:min	Maximum Outflow CFS
2	6.064	12	49.210	100	3 15:11	2.90
3	0.141	0	0.301	1	4 18:24	3.03

****
Outfall Loading Summary
****

Outfall Node	Flow Freq. Pcnt.	Avg. Flow CFS	Max. Flow CFS	Total Volume 10^6 gal
Out1	88.56	2.33	6.66	12.001
System	88.56	2.33	6.66	12.001

****
Link Flow Summary
****

Link	Type	Maximum |Flow| CFS	Time of Max Occurrence days	hr:min	Maximum Velocity ft/sec	Max/ Full Flow	Max/ Full Depth
C1	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
C5	CONDUIT	0.31	4	00:01	3.70	0.02	0.13
C6	CONDUIT	0.31	4	00:01	2.74	0.01	0.03
C7	CONDUIT	0.31	4	00:01	2.60	0.03	0.17
C127	CONDUIT	0.31	4	00:02	4.44	0.01	0.12
C10	CONDUIT	0.57	3	21:31	2.35	0.12	0.24
C11	CONDUIT	0.57	4	00:01	1.49	0.03	0.19
C12	CONDUIT	0.92	4	00:01	1.65	0.05	0.25
C14	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
C15	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
C16	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
C18	CONDUIT	0.15	3	19:17	2.05	0.00	0.02
C20	CONDUIT	0.03	4	00:02	0.77	0.00	0.05
C21	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
C22	CONDUIT	0.10	3	21:48	1.26	0.00	0.02
C23	CONDUIT	0.12	4	00:02	1.38	0.02	0.14
C24	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
C25	CONDUIT	0.30	3	20:35	1.58	0.05	0.23
C26	CONDUIT	0.31	3	20:56	5.11	0.01	0.11
C27	CONDUIT	1.09	4	00:01	2.41	0.02	0.15
C28	CONDUIT	1.49	3	21:18	12.44	0.01	0.08
C29	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
C30	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
C31	CONDUIT	0.37	4	00:01	1.31	0.02	0.16
C32	CONDUIT	0.47	4	00:02	1.38	0.03	0.19
C33	CONDUIT	0.69	4	00:00	1.47	0.02	0.06
C34	CONDUIT	0.85	4	00:01	2.51	0.01	0.11
C35	CONDUIT	1.47	4	00:00	3.44	0.01	0.09
C36	CONDUIT	3.30	4	00:00	4.19	0.03	0.12
C37	CONDUIT	3.96	4	00:00	3.49	0.05	0.15
C38	CONDUIT	3.96	4	00:00	4.73	0.03	0.12
C39	CONDUIT	3.96	4	00:00	5.36	0.03	0.11
C40	CONDUIT	0.39	4	00:05	2.17	0.01	0.08
C41	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
C42	CONDUIT	1.16	4	00:01	1.97	0.03	0.16
C43	CONDUIT	1.23	4	00:04	1.29	0.05	0.22
C44	CONDUIT	0.21	4	00:00	3.01	0.01	0.09
C45	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
C46	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
C47	CONDUIT	0.08	4	00:00	0.62	0.01	0.03
C49	CONDUIT	1.59	3	19:22	1.80	0.02	0.06
C50	CONDUIT	2.14	4	00:08	1.58	0.05	0.22
C51	CONDUIT	2.49	4	00:04	1.89	0.03	0.17
C52	CONDUIT	3.60	4	00:01	1.90	0.04	0.20
C53	CONDUIT	4.72	4	00:00	1.78	0.04	0.08
C54	CONDUIT	4.72	4	00:02	1.97	0.03	0.08
C55	CONDUIT	0.09	4	00:00	2.78	0.00	0.05
C56	CONDUIT	0.09	4	00:01	0.66	0.01	0.02
C57	CONDUIT	0.06	4	00:00	2.65	0.00	0.04
C58	CONDUIT	0.33	4	00:02	2.29	0.02	0.15
C59	CONDUIT	0.38	4	00:01	1.90	0.04	0.18
C60	CONDUIT	0.21	4	00:01	3.68	0.01	0.08
C61	CONDUIT	0.71	4	00:02	1.28	0.04	0.10
C63	CONDUIT	0.71	4	00:02	7.68	0.00	0.03
C64	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
C65	CONDUIT	0.20	4	00:00	1.13	0.01	0.03
C68	CONDUIT	4.73	4	00:05	1.80	0.03	0.08
C69	CONDUIT	0.20	4	00:07	1.12	0.03	0.17
C71	CONDUIT	0.38	3	21:31	4.52	0.02	0.14
C73	CONDUIT	0.09	4	00:04	1.38	0.03	0.15
C74	CONDUIT	0.32	3	16:01	1.81	0.02	0.11
C75	CONDUIT	0.07	4	00:03	1.75	0.01	0.08

C76	CONDUIT	0.44	4	00:04	1.15	0.09	0.28
C77	CONDUIT	0.48	4	00:01	2.64	0.03	0.17
C78	CONDUIT	0.57	4	00:00	2.88	0.20	0.30
C80	CONDUIT	0.58	4	00:01	4.15	0.02	0.14
C81	CONDUIT	6.66	3	16:50	2.01	0.01	0.04
C82	CONDUIT	6.66	3	16:50	2.07	0.01	0.04
C83	CONDUIT	0.03	4	00:01	1.96	0.00	0.03
C84	CONDUIT	6.03	4	00:00	1.65	0.02	0.05
C85	CONDUIT	6.06	4	00:01	1.63	0.02	0.05
C86	CONDUIT	6.07	4	00:02	1.59	0.01	0.05
C87	CONDUIT	4.73	4	00:05	2.11	0.03	0.07
C88	CONDUIT	4.73	4	00:06	2.91	0.02	0.05
C89	CONDUIT	4.72	4	00:08	3.99	0.01	0.04
C90	CONDUIT	0.44	3	21:32	1.10	0.00	0.01
C91	CONDUIT	1.18	4	00:00	5.39	0.04	0.19
C92	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
C93	CONDUIT	1.18	4	00:04	0.90	0.00	0.02
C125	CONDUIT	6.66	3	16:50	23.59	0.32	0.39
C128	CONDUIT	0.00	4	00:12	0.41	0.00	0.01
C129	CONDUIT	0.28	4	00:00	1.08	0.01	0.03
C130	CONDUIT	0.12	4	00:02	2.19	0.01	0.08
C131	CONDUIT	3.96	4	00:00	9.09	0.01	0.08
C132	CONDUIT	3.96	4	00:00	17.71	0.23	0.33
C133	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
C135	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
C136	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
C137	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
C138	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
C139	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
C140	CONDUIT	3.13	4	18:23	4.38	1.08	0.93
weir	WEIR	3.03	4	18:24			0.00

****
Conduit Surcharge Summary
****

Conduit	Hours Full Both Ends	Hours Full Upstream	Hours Full Dnstream	Hours Above Full Normal Flow	Hours Capacity Limited
C140	0.01	40.80	0.01	40.77	40.80

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Analysis begun on:  Sun May 09 17:03:28 2010
Analysis ended on:  Sun May 09 17:03:42 2010
Total elapsed time: 00:00:14
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STATUS REPORT (EPA SWMM)

BY USING TIME SERIES 2

Runoff Quantity Continuity	Volume acre-feet	Depth inches
Total Precipitation	517.923	8.710
Evaporation Loss	0.000	0.000
Infiltration Loss	98.245	1.652
Surface Runoff	424.728	7.143
Final Surface Storage	1.044	0.018
Continuity Error (%)	-1.177	

Flow Routing Continuity	Volume acre-feet	Volume 10^6 gal
Dry Weather Inflow	0.000	0.000
Wet Weather Inflow	425.081	138.519
Groundwater Inflow	0.000	0.000
RDII Inflow	0.000	0.000
External Inflow	0.000	0.000
External Outflow	21.842	7.117
Internal Outflow	404.974	131.967
Storage Losses	0.000	0.000
Initial Stored Volume	0.000	0.000
Final Stored Volume	0.000	0.000
Continuity Error (%)	-0.408	

Highest Flow Instability Indexes

All links are stable.

Routing Time Step Summary

Minimum Time Step	:	30.00 sec
Average Time Step	:	30.00 sec
Maximum Time Step	:	30.00 sec
Percent in Steady State	:	0.00
Average Iterations per Step	:	1.01

Subcatchment Runoff Summary

Subcatchment	Total Precip in	Total Runon in	Total Evap in	Total Infil in	Total Runoff in	Total Runoff 10^6 gal	Peak Runoff CFS	Runoff Coeff
S4(3)	8.710	0.000	0.000	5.276	3.444	12.335	313.654	0.395
S4(4)	8.710	0.000	0.000	1.787	6.982	0.074	5.978	0.802
S4(5)	8.710	0.000	0.000	0.703	8.116	0.207	30.493	0.932
S4(6)	8.710	0.000	0.000	1.000	7.817	0.384	45.174	0.897
S4(7)	8.710	0.000	0.000	0.287	8.562	0.560	75.717	0.983
S4(8)	8.710	0.000	0.000	0.281	8.571	0.687	93.630	0.984
S4(9)	8.710	0.000	0.000	1.233	7.570	1.059	106.585	0.869
S4(10)	8.710	0.000	0.000	0.818	8.013	0.235	28.991	0.920
S4(11)	8.710	0.000	0.000	0.603	8.242	0.251	33.140	0.946
S4(12)	8.710	0.000	0.000	0.557	8.291	0.257	35.270	0.952
S4(13)	8.710	0.000	0.000	0.489	8.346	0.020	2.950	0.958
S4(14)	8.710	0.000	0.000	0.873	7.945	0.123	16.033	0.912
S4(15)	8.710	0.000	0.000	0.944	7.873	0.203	24.965	0.904
S4(16)	8.710	0.000	0.000	0.398	8.462	0.253	35.563	0.972
S4(17)	8.710	0.000	0.000	0.533	8.313	0.104	14.550	0.954
S4(18)	8.710	0.000	0.000	0.767	8.067	0.425	54.600	0.926
S4(19)	8.710	0.000	0.000	0.592	8.226	0.047	6.868	0.944
S4(20)	8.710	0.000	0.000	0.192	8.668	0.991	138.213	0.995
S4(21)	8.710	0.000	0.000	0.120	8.737	0.619	86.054	1.003

S4(22)	8.710	0.000	0.000	0.973	7.844	0.126	15.087	0.901
S4(23)	8.710	0.000	0.000	0.264	8.598	0.149	20.901	0.987
S4(24)	8.710	0.000	0.000	1.009	7.806	0.110	12.863	0.896
S4(25)	8.710	0.000	0.000	0.241	8.626	0.089	12.775	0.990
S4(26)	8.710	0.000	0.000	0.251	8.616	0.098	13.964	0.989
S4(27)	8.710	0.000	0.000	0.678	8.156	2.604	323.319	0.936
S4(28)	8.710	0.000	0.000	1.349	7.446	2.535	240.587	0.855
S4(29)	8.710	0.000	0.000	0.893	7.931	1.010	117.793	0.911
S5(1)	8.710	0.000	0.000	2.130	6.633	3.460	228.368	0.762
S5(2)	8.710	0.000	0.000	2.010	6.755	1.787	123.570	0.776
S5(3)	8.710	0.000	0.000	0.124	8.726	2.130	291.285	1.002
S5(4)	8.710	0.000	0.000	1.870	6.899	2.772	204.598	0.792
S5(5)	8.710	0.000	0.000	0.133	8.701	1.581	206.749	0.999
S5(6)	8.710	0.000	0.000	0.275	8.581	1.296	178.507	0.985
S5(7)	8.710	0.000	0.000	0.117	8.745	4.250	596.535	1.004
S6(1)	8.710	0.000	0.000	0.164	8.700	0.257	37.331	0.999
S6(2)	8.710	0.000	0.000	0.210	8.633	2.218	296.268	0.991
S6(3)	8.710	0.000	0.000	0.248	8.557	4.006	465.282	0.983
S6(4)	8.710	0.000	0.000	0.142	8.675	2.374	291.657	0.996
S6(5)	8.710	0.000	0.000	0.150	8.654	4.836	559.464	0.994
S7(1)	8.710	0.000	0.000	1.618	7.157	8.590	736.243	0.822
S7(2)	8.710	0.000	0.000	1.474	7.306	1.573	149.992	0.839
S7(3)	8.710	0.000	0.000	0.236	8.630	2.484	358.068	0.991
S7(4)	8.710	0.000	0.000	0.106	8.763	0.583	84.025	1.006
S7(5)	8.710	0.000	0.000	0.119	8.741	1.946	271.953	1.004
S8(1)	8.710	0.000	0.000	1.454	7.327	3.088	299.215	0.841
S8(2)	8.710	0.000	0.000	1.270	7.523	1.834	208.363	0.864
S8(3)	8.710	0.000	0.000	0.279	8.574	1.080	147.828	0.984
S8(4)	8.710	0.000	0.000	0.141	8.679	2.474	307.389	0.996
S8(5)	8.710	0.000	0.000	0.744	8.090	0.176	23.007	0.929
S8(6)	8.710	0.000	0.000	0.854	7.974	0.201	24.169	0.916
S8(7)	8.710	0.000	0.000	0.359	8.490	0.212	30.733	0.975
S8(8)	8.710	0.000	0.000	0.992	7.822	0.739	80.770	0.898
S8(11)	8.710	0.000	0.000	0.880	7.945	2.065	243.099	0.912
S8(12)	8.710	0.000	0.000	0.123	8.729	2.609	358.268	1.002
S9(1)	8.710	0.000	0.000	0.137	8.689	2.855	364.011	0.998
S9(2)	8.710	0.000	0.000	0.142	8.674	6.934	851.547	0.996
S9(3)	8.710	0.000	0.000	0.104	8.760	0.540	78.142	1.006
S9(4)	8.710	0.000	0.000	0.108	8.763	0.167	23.929	1.006
S9(5)	8.710	0.000	0.000	0.118	8.744	0.038	5.326	1.004
S9(6)	8.710	0.000	0.000	0.114	8.754	0.033	4.720	1.005
S9(7)	8.710	0.000	0.000	0.108	8.763	0.083	11.971	1.006
S9(8)	8.710	0.000	0.000	0.119	8.741	0.660	92.110	1.004
S9(9)	8.710	0.000	0.000	0.109	8.762	0.233	33.430	1.006
S9(10)	8.710	0.000	0.000	0.116	8.748	0.401	56.583	1.004
S9(11)	8.710	0.000	0.000	0.107	8.830	0.072	10.279	1.014
S9(12)	8.710	0.000	0.000	0.114	8.754	0.841	119.339	1.005
S9(13)	8.710	0.000	0.000	0.121	8.736	1.056	146.525	1.003
S9(14)	8.710	0.000	0.000	0.125	8.723	0.928	126.310	1.001
S9(15)	8.710	0.000	0.000	0.106	8.763	0.352	50.793	1.006
S9(16)	8.710	0.000	0.000	0.763	8.056	1.525	176.699	0.925
S9(17)	8.710	0.000	0.000	0.652	8.187	0.482	61.211	0.940
S9(18)	8.710	0.000	0.000	0.826	8.004	0.517	63.385	0.919
S9(19)	8.710	0.000	0.000	0.921	7.900	0.944	108.029	0.907
S10(2)	8.710	0.000	0.000	0.141	8.679	4.096	508.400	0.996
S10(3)	8.710	0.000	0.000	0.108	8.763	0.345	49.599	1.006
S10(4)	8.710	0.000	0.000	0.104	8.761	0.076	11.013	1.006
S10(5)	8.710	0.000	0.000	0.104	8.761	0.067	9.635	1.006
S10(6)	8.710	0.000	0.000	0.673	8.162	1.387	172.988	0.937
S10(7)	8.710	0.000	0.000	0.666	8.171	0.803	100.731	0.938
S10(8)	8.710	0.000	0.000	0.535	8.311	0.230	32.195	0.954
S10(9)	8.710	0.000	0.000	0.134	8.697	4.801	622.273	0.999
S10(10)	8.710	0.000	0.000	0.504	8.335	0.274	39.197	0.957
S10(11)	8.710	0.000	0.000	0.715	8.118	0.265	35.459	0.932
S10(12)	8.710	0.000	0.000	0.494	8.302	0.133	20.005	0.953
S10(13)	8.710	0.000	0.000	0.690	8.141	0.263	35.976	0.935
S10(14)	8.710	0.000	0.000	0.662	8.167	0.122	17.055	0.938
S10(15)	8.710	0.000	0.000	1.723	7.044	3.644	302.126	0.809
S10(16)	8.710	0.000	0.000	1.261	7.556	0.521	66.346	0.867
S11(1)	8.710	0.000	0.000	0.583	8.265	1.620	217.998	0.949
S11(2)	8.710	0.000	0.000	0.647	8.193	0.672	85.641	0.941
S11(3)	8.710	0.000	0.000	0.815	8.016	0.148	18.299	0.920

S11(4)	8.710	0.000	0.000	0.892	7.932	0.127	14.838	0.911
S11(5)	8.710	0.000	0.000	0.828	8.002	0.200	24.474	0.919
S11(6)	8.710	0.000	0.000	1.024	7.786	0.943	101.042	0.894
S11(7)	8.710	0.000	0.000	0.729	8.104	0.057	7.581	0.930
S11(8)	8.710	0.000	0.000	0.738	8.096	0.057	7.521	0.930
S11(9)	8.710	0.000	0.000	1.645	7.127	1.209	107.346	0.818
S11(10)	8.710	0.000	0.000	0.868	7.959	0.313	37.230	0.914
S11(11)	8.710	0.000	0.000	0.797	8.035	0.179	22.443	0.923
S11(12)	8.710	0.000	0.000	0.912	7.910	0.137	15.828	0.908
S11(13)	8.710	0.000	0.000	1.716	7.052	2.742	228.726	0.810
S11(14)	8.710	0.000	0.000	1.612	7.162	3.199	292.611	0.822
S11(15)	8.710	0.000	0.000	1.582	7.203	0.156	13.479	0.827
S11(16)	8.710	0.000	0.000	1.609	7.175	0.177	15.083	0.824
S11(17)	8.710	0.000	0.000	1.722	7.051	2.110	169.116	0.810
S11(18)	8.710	0.000	0.000	1.567	7.210	2.480	220.401	0.828
System	8.710	0.000	0.000	1.652	7.143	138.394	14715.445	0.820

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Node Depth Summary
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Node	Type	Average Depth Feet	Maximum Depth Feet	Maximum HGL Feet	Time of Max Occurrence days	hr:min
OA	JUNCTION	0.00	0.00	129.33	0	00:00
A	JUNCTION	0.01	3.28	126.51	0	00:09
A1	JUNCTION	0.02	3.28	125.98	0	00:06
OA2	JUNCTION	0.00	0.00	129.53	0	00:00
A2	JUNCTION	0.08	13.12	133.56	0	00:05
A3	JUNCTION	0.01	1.31	121.65	0	00:06
B	JUNCTION	0.15	6.89	134.18	0	00:07
B1	JUNCTION	0.00	0.00	119.98	0	00:00
B2	JUNCTION	0.00	0.00	117.69	0	00:00
B3	JUNCTION	0.00	0.00	113.19	0	00:00
B31	JUNCTION	0.01	6.89	106.48	0	00;10
B4	JUNCTION	0.01	6.89	114.50	0	00:10
B5	JUNCTION	0.02	6.89	113.55	0	00:11
B6	JUNCTION	0.06	6.89	103.54	0	00:06
B61	JUNCTION	0.00	0.00	97.47	0	00:00
B7	JUNCTION	0.09	9.84	105.18	0	00:06
B8	JUNCTION	0.06	9.84	104.85	0	00:08
C	JUNCTION	0.20	6.89	133.86	0	00:06
C1	JUNCTION	0.05	1.31	119.75	0	00:06
C2	JUNCTION	0.22	6.89	123.03	0	00:06
C3	JUNCTION	0.05	1.31	115.98	0	00:07
C5	JUNCTION	0.26	6.89	106.66	0	00:05
C6	JUNCTION	0.05	1.31	100.75	0	00:06
C7	JUNCTION	0.06	6.89	105.32	0	00:06
C8	JUNCTION	0.06	6.89	104.46	0	00:08
C9	JUNCTION	0.06	6.89	103.08	0	00:08
C91	JUNCTION	0.56	6.89	35.73	0	00:05
C10	JUNCTION	0.00	0.00	98.81	0	00:00
OD	JUNCTION	0.00	0.00	98.49	0	00:00
D	JUNCTION	0.05	6.89	104.99	0	00:06
D1	JUNCTION	0.06	6.89	103.87	0	00:06
D2	JUNCTION	0.05	9.84	106.10	0	00:07
D3	JUNCTION	0.04	6.89	102.69	0	00:08
D4	JUNCTION	0.04	6.89	100.53	0	00:08
D5	JUNCTION	0.07	13.12	103.74	0	00:06
D6	JUNCTION	0.08	13.12	99.87	0	00:07
D7	JUNCTION	0.04	3.93	90.07	0	00:07
D8	JUNCTION	0.03	2.38	87.02	0	01:03
D9	JUNCTION	0.03	2.12	85.64	0	01:03
D10	JUNCTION	0.15	13.12	92.68	0	00:10
F	JUNCTION	0.00	0.00	132.48	0	00:00
F1	JUNCTION	0.04	6.89	105.81	0	00:06
OF11	JUNCTION	0.00	0.00	135.46	0	00:00
F11	JUNCTION	0.02	6.89	105.97	0	00:08

G	JUNCTION	0.08	9.84	104.66	0	00:06
G1	JUNCTION	0.06	9.84	103.38	0	00:09
G2	JUNCTION	0.09	13.12	106.07	0	00:08
G3	JUNCTION	0.09	13.12	105.44	0	00:08
G4	JUNCTION	0.04	5.41	97.44	0	00:09
G5	JUNCTION	0.04	13.12	104.66	0	00:50
G6	JUNCTION	0.04	5.02	95.96	0	00:55
G7	JUNCTION	0.03	4.05	94.67	0	00:55
G8	JUNCTION	0.02	2.73	93.02	0	00:56
OH	JUNCTION	0.01	6.89	123.12	0	00:09
H	JUNCTION	0.02	6.89	110.64	0	00:08
OH1	JUNCTION	0.01	6.89	122.10	0	00:12
H1	JUNCTION	0.03	6.89	110.54	0	00:06
H2	JUNCTION	0.03	6.89	104.73	0	00:07
H3	JUNCTION	0.02	6.89	134.28	0	00:08
H4	JUNCTION	0.03	6.89	106.39	0	00:06
H5	JUNCTION	0.01	1.97	99.64	0	00:08
OI	JUNCTION	0.00	0.00	130.30	0	00:00
I	JUNCTION	0.02	6.89	124.50	0	00:08
I1	JUNCTION	0.04	6.89	123.98	0	00:06
I2	JUNCTION	0.04	6.89	122.06	0	00:07
I3	JUNCTION	0.01	1.96	102.78	0	00:20
I4	JUNCTION	0.04	6.89	107.44	0	00:06
I5	JUNCTION	0.02	1.97	83.36	0	00:07
I6	JUNCTION	0.00	0.00	84.95	0	00:00
OJ	JUNCTION	0.03	6.89	139.25	0	00:07
J1	JUNCTION	0.05	6.89	122.82	0	00:06
OJ1	JUNCTION	0.06	6.89	127.51	0	00:05
J2	JUNCTION	0.07	6.89	122.56	0	00:05
OJ2	JUNCTION	0.05	6.89	134.20	0	00:06
J3	JUNCTION	0.05	6.89	122.05	0	00:08
J4	JUNCTION	0.08	6.89	109.25	0	00:05
J5	JUNCTION	0.03	13.12	113.90	0	00:14
J6	JUNCTION	0.03	5.60	85.59	0	00:22
J7	JUNCTION	0.03	4.71	84.40	0	00:23
K	JUNCTION	0.01	6.89	121.80	0	00:17
K1	JUNCTION	0.03	5.42	86.39	0	00:20
K2	JUNCTION	0.04	13.12	93.66	0	00:19
K3	JUNCTION	0.03	6.15	86.46	0	00:22
M	JUNCTION	0.00	0.00	127.15	0	00:00
M1	JUNCTION	0.01	1.51	131.71	0	00:20
J92	JUNCTION	0.13	13.12	92.68	0	00:06
J93	JUNCTION	0.00	0.00	127.29	0	00:00
J94	JUNCTION	0.00	0.00	113.19	0	00:00
J95	JUNCTION	0.00	0.00	114.67	0	00:00
J96	JUNCTION	0.00	0.00	115.17	0	00:00
J97	JUNCTION	0.00	0.00	100.78	0	00:00
J98	JUNCTION	0.00	0.00	114.91	0	00:00
J99	JUNCTION	0.00	0.00	19.69	0	00:00
Out1	OUTFALL	0.02	1.00	1.00	0	00:11
2	STORAGE	1.36	49.21	74.73	0	01:04
3	STORAGE	0.01	0.30	24.25	0	09:03

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Node InFlow Summary
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Node	Type	Maximum Lateral Inflow CFS	Maximum Total Inflow CFS	Time of Max Occurrence days	hr:min	Lateral Inflow Volume 10^6 gal	Total Inflow Volume 10^6 gal
OA	JUNCTION	0.00	0.00	0	00:00	0.000	0.000
A	JUNCTION	120.89	120.89	0	00:20	0.946	0.946
A1	JUNCTION	28.99	56.36	0	00:20	0.235	0.718
OA2	JUNCTION	0.00	0.00	0	00:00	0.000	0.000
A2	JUNCTION	233.35	240.05	0	00:20	1.998	2.188
A3	JUNCTION	16.03	21.78	0	00:20	0.123	0.374
B	JUNCTION	383.34	386.89	0	00:20	12.888	12.962
B1	JUNCTION	0.00	0.00	0	00:00	0.000	0.000

B2	JUNCTION	0.00	0.00	0	00:00	0.000	0.000
B3	JUNCTION	0.00	0.00	0	00:00	0.000	0.000
B31	JUNCTION	159.11	159.11	0	00:20	1.142	1.142
B4	JUNCTION	42.43	42.43	0	00:20	0.300	0.300
B5	JUNCTION	77.73	113.97	0	00:20	0.585	1.161
B6	JUNCTION	1328.33	1385.95	0	00:20	13.242	14.240
B61	JUNCTION	0.00	0.00	0	00:00	0.000	0.000
B7	JUNCTION	208.36	252.90	0	00:20	1.836	3.898
B8	JUNCTION	178.56	228.20	0	00:20	1.294	3.497
C	JUNCTION	43.36	82.86	0	00:20	0.318	6.648
C1	JUNCTION	0.00	18.43	0	00:06	0.000	3.563
C2	JUNCTION	0.00	19.62	0	00:07	0.000	3.563
C3	JUNCTION	0.00	11.32	0	00:07	0.000	2.377
C5	JUNCTION	336.09	347.42	0	00:20	2.696	5.073
C6	JUNCTION	0.00	4.98	0	07:56	0.000	1.084
C7	JUNCTION	254.55	305.17	0	00:20	2.636	4.405
C8	JUNCTION	203.85	221.88	0	00:20	1.631	3.327
C9	JUNCTION	500.32	548.90	0	00:20	5.410	7.739
C91	JUNCTION	0.00	113.54	0	00:47	0.000	4.659
C10	JUNCTION	0.00	0.00	0	00:00	0.000	0.000
OD	JUNCTION	0.00	0.00	0	00:00	0.000	0.000
D	JUNCTION	414.86	414.86	0	00:20	3.920	3.920
D1	JUNCTION	204.60	220.61	0	00:20	2.774	3.557
D2	JUNCTION	206.75	222.34	0	00:20	1.582	2.528
D3	JUNCTION	178.51	215.54	0	00:20	1.297	2.716
D4	JUNCTION	633.87	700.89	0	00:20	4.514	6.453
D5	JUNCTION	1612.67	1792.00	0	00:20	13.443	17.247
D6	JUNCTION	622.27	736.82	0	00:20	4.805	8.893
D7	JUNCTION	0.00	85.59	0	01:03	0.000	3.481
D8	JUNCTION	0.00	85.53	0	01:03	0.000	3.480
D9	JUNCTION	0.00	85.31	0	01:03	0.000	3.479
D10	JUNCTION	0.00	432.07	0	00:23	0.000	8.964
F	JUNCTION	0.00	0.00	0	00:00	0.000	0.000
F1	JUNCTION	322.22	335.94	0	00:20	3.266	3.621
OF11	JUNCTION	0.00	0.00	0	00:00	0.000	0.000
F11	JUNCTION	104.94	104.94	0	00:20	0.941	0.941
G	JUNCTION	601.37	681.96	0	00:20	4.679	7.418
G1	JUNCTION	331.32	375.29	0	00:20	2.643	4.933
G2	JUNCTION	369.34	473.99	0	00:20	2.895	6.610
G3	JUNCTION	1074.27	1159.74	0	00:20	8.595	12.231
G4	JUNCTION	0.00	152.62	0	00:50	0.000	5.184
G5	JUNCTION	0.00	146.94	0	00:51	0.000	5.188
G6	JUNCTION	0.00	152.22	0	00:55	0.000	5.196
G7	JUNCTION	0.00	149.27	0	00:55	0.000	5.196
G8	JUNCTION	0.00	147.97	0	00:56	0.000	5.196
OH	JUNCTION	90.11	90.11	0	00:20	0.624	0.624
H	JUNCTION	0.00	31.58	0	00:10	0.000	0.410
OH1	JUNCTION	61.07	61.07	0	00:20	0.425	0.425
H1	JUNCTION	182.89	234.46	0	00:20	1.331	1.948
H2	JUNCTION	0.00	25.03	0	00:07	0.000	0.611
H3	JUNCTION	211.45	211.45	0	00:20	1.503	1.503
H4	JUNCTION	179.95	212.84	0	00:20	1.290	1.851
H5	JUNCTION	0.00	20.92	0	00:49	0.000	0.470
OI	JUNCTION	0.00	0.00	0	00:00	0.000	0.000
I	JUNCTION	237.91	237.91	0	00:20	2.009	2.009
I1	JUNCTION	0.00	36.13	0	00:41	0.000	0.728
I2	JUNCTION	242.21	248.33	0	00:20	2.078	2.337
I3	JUNCTION	60.61	86.03	0	00:20	0.422	1.229
I4	JUNCTION	723.22	808.85	0	00:20	5.785	7.014
I5	JUNCTION	0.00	29.54	0	00:07	0.000	1.149
I6	JUNCTION	0.00	0.00	0	00:00	0.000	0.000
OJ	JUNCTION	171.41	171.41	0	00:20	1.463	1.463
J1	JUNCTION	242.84	265.40	0	00:20	2.661	3.362
OJ1	JUNCTION	184.20	184.20	0	00:20	2.289	2.289
J2	JUNCTION	228.73	252.36	0	00:20	2.743	3.866
OJ2	JUNCTION	306.09	306.09	0	00:20	3.358	3.358
J3	JUNCTION	130.69	135.78	0	00:20	1.405	1.741
J4	JUNCTION	338.10	356.34	0	00:20	3.909	4.677
J5	JUNCTION	66.35	69.26	0	00:20	0.522	0.737
J6	JUNCTION	17.05	438.90	0	00:22	0.122	8.963
J7	JUNCTION	0.00	432.60	0	00:23	0.000	8.964
K	JUNCTION	46.89	46.89	0	00:20	0.385	0.385

K1	JUNCTION	136.19	336.82	0	00:20	1.069	7.803
K2	JUNCTION	39.20	370.02	0	00:20	0.274	8.082
K3	JUNCTION	20.01	403.51	0	00:22	0.133	8.214
M	JUNCTION	0.00	0.00	0	00:00	0.000	0.000
M1	JUNCTION	5.98	5.98	0	00:20	0.074	0.074
J92	JUNCTION	0.00	85.21	0	01:04	0.000	3.479
J93	JUNCTION	0.00	0.00	0	00:00	0.000	0.000
J94	JUNCTION	0.00	0.00	0	00:00	0.000	0.000
J95	JUNCTION	0.00	0.00	0	00:00	0.000	0.000
J96	JUNCTION	0.00	0.00	0	00:00	0.000	0.000
J97	JUNCTION	0.00	0.00	0	00:00	0.000	0.000
J98	JUNCTION	0.00	0.00	0	00:00	0.000	0.000
J99	JUNCTION	0.00	3.00	0	09:03	0.000	0.719
Out1	OUTFALL	0.00	22.35	0	02:30	0.000	1.739
2	STORAGE	0.00	18.07	0	02:04	0.000	1.278
3	STORAGE	0.00	3.13	0	09:02	0.000	0.719

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Node Surcharge Summary
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Surcharging occurs when water rises above the top of the highest conduit.

Node	Type	Hours Surcharged	Max. Height Above Crown Feet	Min. Depth Below Rim Feet
A	JUNCTION	0.47	1.310	0.000
A1	JUNCTION	0.78	1.310	0.000
A2	JUNCTION	1.23	11.810	0.000
A3	JUNCTION	1.22	0.000	1.970
B	JUNCTION	4.00	4.920	0.000
B31	JUNCTION	0.39	4.920	0.000
B4	JUNCTION	0.35	4.590	0.000
B5	JUNCTION	0.33	3.610	0.000
B6	JUNCTION	1.31	3.280	0.000
B7	JUNCTION	1.59	6.230	0.000
B8	JUNCTION	0.50	5.900	0.000
C	JUNCTION	5.78	4.920	0.000
C2	JUNCTION	6.68	4.920	0.000
C3	JUNCTION	6.67	0.000	5.580
C5	JUNCTION	7.92	5.580	0.000
C6	JUNCTION	7.84	0.000	5.580
C7	JUNCTION	1.18	4.920	0.000
C8	JUNCTION	0.54	3.940	0.000
C9	JUNCTION	0.69	3.940	0.000
C91	JUNCTION	17.61	4.920	0.000
D	JUNCTION	1.19	5.250	0.000
D1	JUNCTION	1.69	5.250	0.000
D2	JUNCTION	0.59	7.870	0.000
D3	JUNCTION	0.51	3.450	0.000
D4	JUNCTION	0.48	1.970	0.000
D5	JUNCTION	0.81	8.200	0.000
D6	JUNCTION	0.96	9.190	0.000
D7	JUNCTION	0.93	0.000	5.910
D10	JUNCTION	2.39	6.230	0.000
F1	JUNCTION	0.97	4.920	0.000
F11	JUNCTION	0.63	4.920	0.000
G	JUNCTION	1.21	5.900	0.000
G1	JUNCTION	0.55	4.920	0.000
G2	JUNCTION	0.78	7.710	0.000
G3	JUNCTION	0.79	7.710	0.000
G4	JUNCTION	0.68	0.000	7.710
G5	JUNCTION	0.08	7.710	0.000
OH	JUNCTION	0.27	4.920	0.000
H	JUNCTION	0.47	3.940	0.000
OH1	JUNCTION	0.19	4.920	0.000
H1	JUNCTION	0.64	3.940	0.000
H2	JUNCTION	0.75	4.920	0.000
H3	JUNCTION	0.50	4.920	0.000
H4	JUNCTION	0.72	4.920	0.000

I	JUNCTION	0.60	4.920	0.000
I1	JUNCTION	1.06	4.920	0.000
I2	JUNCTION	1.08	4.920	0.000
I4	JUNCTION	0.98	0.990	0.000
OJ	JUNCTION	0.64	4.920	0.000
J1	JUNCTION	1.34	4.920	0.000
OJ1	JUNCTION	1.88	5.580	0.000
J2	JUNCTION	2.13	4.920	0.000
OJ2	JUNCTION	1.29	5.250	0.000
J3	JUNCTION	2.12	4.920	0.000
J4	JUNCTION	2.42	5.580	0.000
J5	JUNCTION	0.30	11.810	0.000
K	JUNCTION	0.08	4.920	0.000
K2	JUNCTION	0.05	6.230	0.000
J92	JUNCTION	2.01	9.190	0.000
2	STORAGE	8.88	48.210	0.000

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Node Flooding Summary
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Flooding refers to all water that overflows a node, whether it ponds or not.

Node	Hours Flooded	Maximum Rate CFS	Time of Max Occurrence days hr:min	Total Flood Volume 10^6 gal	Maximum Ponded Volume acre-in
A	0.47	91.39	0 00:20	0.464	0.00
A1	0.78	49.15	0 00:20	0.532	0.00
A2	1.23	230.20	0 00:20	1.937	0.00
B	4.00	340.14	0 00:20	6.675	0.00
B31	0.39	110.71	0 00:20	0.461	0.00
B4	0.35	27.15	0 00:20	0.100	0.00
B5	0.33	54.74	0 00:20	0.184	0.00
B6	1.31	1315.62	0 00:20	12.207	0.00
B7	1.59	224.03	0 00:20	2.603	0.00
B8	0.50	144.78	0 00:20	0.766	0.00
C	5.78	63.71	0 00:20	3.086	0.00
C2	6.68	7.45	0 00:07	1.187	0.00
C5	7.92	336.92	0 00:20	3.990	0.00
C7	1.18	282.35	0 00:20	2.715	0.00
C8	0.54	169.84	0 00:20	1.001	0.00
C9	0.69	433.29	0 00:20	3.081	0.00
C91	17.61	0.00	0 00:00	0.000	0.00
D	1.19	391.45	0 00:20	3.148	0.00
D1	1.69	201.42	0 00:20	2.617	0.00
D2	0.59	181.50	0 00:20	1.114	0.00
D3	0.51	145.67	0 00:20	0.780	0.00
D4	0.48	512.17	0 00:20	2.651	0.00
D5	0.81	1644.00	0 00:20	13.170	0.00
D6	0.96	643.47	0 00:20	5.413	0.00
D10	2.39	408.77	0 00:23	7.226	0.00
F1	0.97	304.73	0 00:20	2.739	0.00
F11	0.63	89.29	0 00:20	0.589	0.00
G	1.21	627.78	0 00:20	5.270	0.00
G1	0.55	281.43	0 00:20	1.701	0.00
G2	0.78	381.39	0 00:20	3.013	0.00
G3	0.76	1005.18	0 00:20	7.072	0.00
G5	0.08	9.15	0 00:51	0.010	0.00
OH	0.27	57.39	0 00:20	0.215	0.00
H	0.47	14.47	0 00:10	0.150	0.00
OH1	0.19	25.84	0 00:20	0.068	0.00
H1	0.64	217.16	0 00:20	1.626	0.00
H2	0.75	7.73	0 00:08	0.144	0.00
H3	0.50	175.47	0 00:20	0.945	0.00
H4	0.72	199.42	0 00:20	1.575	0.00
I	0.60	202.83	0 00:20	1.283	0.00
I1	1.06	28.35	0 00:42	0.494	0.00
I2	0.72	218.57	0 00:20	1.530	0.00
I4	0.98	764.62	0 00:20	5.874	0.00

OJ	0.64	149.28	0	00:20	0.992	0.00
J1	1.34	247.15	0	00:20	2.674	0.00
OJ1	1.88	177.43	0	00:20	2.078	0.00
J2	2.13	244.28	0	00:20	3.539	0.00
OJ2	1.29	291.75	0	00:20	2.935	0.00
J3	0.86	115.44	0	00:20	0.981	0.00
J4	2.42	348.44	0	00:20	4.464	0.00
J5	0.30	35.16	0	00:20	0.111	0.00
K	0.08	8.40	0	00:20	0.010	0.00
K2	0.05	11.04	0	00:20	0.008	0.00
J92	2.01	68.07	0	01:04	2.201	0.00
2	2.22	15.07	0	02:04	0.559	0.00

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Storage Volume Summary
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Storage Unit	Average Volume 1000 ft3	Avg Pcnt Full	Maximum Volume 1000 ft3	Max Pcnt Full	Time of Max Occurrence days hr:min	Maximum Outflow CFS
2	1.360	3	49.210	100	0 01:04	2.90
3	0.014	0	0.300	1	0 09:03	3.00

****
Outfall Loading Summary
****

Outfall Node	Flow Freq. Pcnt.	Avg. Flow CFS	Max. Flow CFS	Total Volume 10^6 gal
Out1	20.32	1.47	22.35	1.739
System	20.32	1.47	22.35	1.739

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Link Flow Summary
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Link	Type	Maximum |Flow| CFS	Time of Max Occurrence days hr:min	Maximum Velocity ft/sec	Max/ Full Flow	Max/ Full Depth
C1	CONDUIT	0.00	0 00:00	0.00	0.00	0.00
C5	CONDUIT	18.43	0 00:06	10.72	1.00	1.00
C6	CONDUIT	19.62	0 00:07	11.80	0.42	0.43
C7	CONDUIT	11.32	0 00:07	6.59	1.00	1.00
C127	CONDUIT	11.32	0 00:08	11.62	0.47	0.68
C10	CONDUIT	4.98	0 07:56	4.02	1.07	1.00
C11	CONDUIT	4.84	0 07:57	2.81	0.26	0.52
C12	CONDUIT	18.03	0 00:07	3.96	1.00	1.00
C14	CONDUIT	0.00	0 00:00	0.00	0.00	0.00
C15	CONDUIT	0.00	0 00:00	0.00	0.00	0.00
C16	CONDUIT	0.00	0 00:00	0.00	0.00	0.00
C18	CONDUIT	52.29	0 00:10	13.95	1.14	1.00
C20	CONDUIT	14.64	0 00:11	3.78	1.00	1.00
C21	CONDUIT	0.00	0 00:00	0.00	0.00	0.00
C22	CONDUIT	31.60	0 00:36	8.31	1.15	1.00
C23	CONDUIT	6.70	0 00:07	4.04	1.00	1.00
C24	CONDUIT	0.00	0 00:00	0.00	0.00	0.00
C25	CONDUIT	5.75	0 00:06	3.34	1.00	1.00
C26	CONDUIT	21.60	0 00:20	15.73	0.75	0.86
C27	CONDUIT	48.58	0 00:08	6.40	1.00	1.00
C28	CONDUIT	113.54	0 00:47	40.25	1.06	1.00
C29	CONDUIT	0.00	0 00:00	0.00	0.00	0.00

C30	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
C31	CONDUIT	16.01	0	00:07	3.77	1.00	1.00
C32	CONDUIT	15.59	0	00:07	3.65	1.00	1.00
C33	CONDUIT	46.17	0	00:39	6.13	1.25	1.00
C34	CONDUIT	67.02	0	00:09	7.68	1.00	1.00
C35	CONDUIT	179.33	0	00:09	11.23	1.00	1.00
C36	CONDUIT	123.35	0	00:55	11.29	1.08	1.00
C37	CONDUIT	85.59	0	01:03	7.85	1.05	1.00
C38	CONDUIT	85.53	0	01:03	11.19	0.68	0.60
C39	CONDUIT	85.31	0	01:03	12.82	0.57	0.54
C40	CONDUIT	57.62	0	00:15	8.03	1.00	1.00
C41	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
C42	CONDUIT	44.54	0	00:07	4.78	1.00	1.00
C43	CONDUIT	24.55	0	00:08	2.66	1.00	1.00
C44	CONDUIT	25.09	0	00:07	9.73	1.00	1.00
C45	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
C46	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
C47	CONDUIT	17.18	0	00:42	4.01	1.25	1.00
C49	CONDUIT	92.31	0	00:09	6.21	1.15	1.00
C50	CONDUIT	43.97	0	00:09	3.38	1.00	1.00
C51	CONDUIT	87.36	0	00:10	4.60	1.00	1.00
C52	CONDUIT	85.48	0	00:10	4.11	1.00	1.00
C53	CONDUIT	152.62	0	00:50	5.22	1.14	1.00
C54	CONDUIT	146.94	0	00:51	5.78	0.94	0.80
C55	CONDUIT	31.58	0	00:10	12.54	1.00	1.00
C56	CONDUIT	17.93	0	00:35	3.51	1.05	1.00
C57	CONDUIT	34.45	0	00:13	13.46	1.00	1.00
C58	CONDUIT	14.35	0	00:07	5.93	1.00	1.00
C59	CONDUIT	10.68	0	00:07	4.32	1.00	1.00
C60	CONDUIT	32.88	0	00:08	13.32	1.00	1.00
C61	CONDUIT	20.92	0	00:49	3.79	1.21	1.00
C63	CONDUIT	20.69	0	00:49	21.10	0.06	0.17
C64	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
C65	CONDUIT	36.13	0	00:41	6.60	1.18	1.00
C68	CONDUIT	152.22	0	00:55	5.40	1.12	0.92
C69	CONDUIT	6.12	0	00:09	2.61	1.00	1.00
C71	CONDUIT	25.42	0	00:07	14.87	1.00	1.00
C73	CONDUIT	3.51	0	00:07	3.23	1.00	1.00
C74	CONDUIT	14.83	0	01:24	5.23	1.08	1.00
C75	CONDUIT	9.87	0	00:08	5.72	1.00	1.00
C76	CONDUIT	5.08	0	00:07	2.09	1.00	1.00
C77	CONDUIT	18.24	0	00:10	7.23	1.00	1.00
C78	CONDUIT	3.14	0	02:31	4.48	1.08	1.00
C80	CONDUIT	32.63	0	00:14	12.78	1.00	1.00
C81	CONDUIT	432.60	0	00:23	8.56	0.77	0.69
C82	CONDUIT	432.07	0	00:23	8.79	0.73	0.66
C83	CONDUIT	37.65	0	00:18	14.96	1.00	1.00
C84	CONDUIT	333.33	0	00:20	6.37	0.91	0.78
C85	CONDUIT	389.29	0	00:22	6.69	1.09	0.92
C86	CONDUIT	394.36	0	00:22	6.66	0.97	0.81
C87	CONDUIT	149.27	0	00:55	6.47	0.85	0.74
C88	CONDUIT	147.97	0	00:56	9.25	0.51	0.50
C89	CONDUIT	146.39	0	00:56	13.43	0.30	0.34
C90	CONDUIT	85.63	0	00:20	7.41	0.29	0.33
C91	CONDUIT	29.54	0	00:07	11.55	1.00	1.00
C92	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
C93	CONDUIT	29.66	0	01:05	3.06	0.10	0.16
C125	CONDUIT	22.35	0	02:30	30.78	1.07	1.00
C128	CONDUIT	5.33	0	00:24	3.48	0.54	0.72
C129	CONDUIT	49.58	0	03:33	6.48	1.25	1.00
C130	CONDUIT	19.04	0	00:09	7.68	1.00	1.00
C131	CONDUIT	85.21	0	01:04	22.47	0.26	0.35
C132	CONDUIT	18.07	0	02:04	25.23	1.06	1.00
C133	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
C135	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
C136	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
C137	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
C138	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
C139	CONDUIT	0.00	0	00:00	0.00	0.00	0.00
C140	CONDUIT	3.13	0	09:02	4.77	1.08	0.92
weir	WEIR	3.00	0	09:03			0.00

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Conduit Surcharge Summary
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Conduit	Hours Full Both Ends	Hours Full Upstream	Hours Full Dnstream	Hours Above Full Normal Flow	Hours Capacity Limited
C5	5.77	5.77	5.77	0.01	5.77
C7	6.67	6.67	6.67	0.01	6.67
C10	7.84	7.91	7.84	7.91	7.91
C12	0.01	1.17	0.01	0.01	1.17
C18	0.34	0.38	0.34	0.04	0.38
C20	0.33	0.34	0.33	0.01	0.34
C22	0.43	0.47	0.43	0.03	0.47
C23	0.74	0.77	0.76	0.01	0.77
C25	1.22	1.23	1.22	0.01	1.23
C27	0.01	0.53	0.01	0.53	0.53
C28	0.66	0.68	0.66	0.03	0.68
C31	1.16	1.18	1.18	0.01	1.18
C32	1.67	1.68	1.68	0.01	1.68
C33	0.51	0.58	0.51	0.58	0.58
C34	0.01	0.50	0.01	0.49	0.50
C35	0.01	0.47	0.01	0.47	0.47
C36	0.78	0.80	0.78	0.82	0.80
C37	0.93	0.95	0.93	0.96	0.95
C40	0.01	0.33	0.03	0.01	0.33
C42	0.01	1.30	0.02	1.30	1.30
C43	0.01	1.58	0.03	1.58	1.58
C44	0.01	0.96	0.01	0.95	0.96
C47	0.56	0.62	0.56	0.07	0.62
C49	0.42	0.49	0.42	0.49	0.49
C50	0.01	1.20	0.04	1.19	1.20
C51	0.01	0.54	0.02	0.01	0.54
C52	0.01	0.77	0.02	0.75	0.77
C53	0.68	0.75	0.68	0.07	0.75
C55	0.01	0.26	0.01	0.01	0.26
C56	0.45	0.47	0.45	0.47	0.47
C57	0.01	0.18	0.01	0.17	0.18
C58	0.01	0.63	0.02	0.01	0.63
C59	0.01	0.72	0.02	0.01	0.72
C60	0.01	0.49	0.01	0.49	0.49
C61	0.69	0.74	0.69	0.74	0.74
C65	0.55	0.59	0.55	0.60	0.59
C68	0.01	0.07	0.01	0.04	0.07
C69	0.01	1.05	0.05	0.01	1.05
C71	0.70	0.71	0.70	0.01	0.71
C73	1.83	1.87	1.88	1.88	1.87
C74	1.29	1.33	1.29	1.33	1.33
C75	1.25	1.28	1.27	1.27	1.28
C76	0.01	2.12	0.03	0.01	2.12
C77	0.01	0.85	0.02	0.83	0.85
C78	2.40	2.41	2.42	2.43	2.41
C80	0.01	0.29	0.01	0.28	0.29
C83	0.01	0.07	0.01	0.07	0.07
C85	0.01	0.04	0.01	0.04	0.04
C91	0.01	0.97	0.02	0.97	0.97
C125	2.33	2.38	2.33	2.38	2.38
C129	3.42	3.99	3.42	4.01	3.99
C130	0.01	0.63	0.02	0.61	0.63
C132	1.95	2.00	1.95	2.00	2.00
C140	0.01	8.92	0.01	0.04	8.92

Analysis begun on: Sun May 09 15:21:53 2010
Analysis ended on: Sun May 09 15:21:56 2010
Total elapsed time: 00:00:03